16(4)

VOL. 16 No. 4 OCTOBER 1954

THE

Progressive Fish-Culturist

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The printing of this publication has been approved by the Director of the Bureau of the Budget, April 8, 1954.

For sale by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Single issue--25¢. Year's subscription--$1 in the United States, possessions, and Canada; plus 30¢ postage in foreign countries. Reprints--Inquire of the Superintendent of Documents, listing complete title, author, volume and issue, pages, and number desired.

THE

Progressive Fish-Culturist

A Quarterly for Fishery Biologists and Fish-Culturists

Volume 16 | Washington, D. C. | October 1954 | Number 4

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A SURVEY OF PRIVATE TROUT ENTERPRISES IN THE WEST

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A SURVEY OF PRIVATE TROUT BUSINESSES in nine Western States was conducted in 1952 and 1953. The States included in the survey were California, Oregon, Washington, Nevada, Colorado, Utah, Wyoming, Montana, and Idaho.

The general purpose of the survey was to obtain an idea of the nature, extent, and location of private live-trout enterprises of all kinds. The study was prompted to some extent by a desire to understand what part private trout culture might be playing in the over-all trout-management picture in the West. It is well known that warm-water farm-pond fish culture of the type practiced in the Midwest and South by private landowners has relieved the fishing pressure on public waters and has contributed to the total production of fish.

It is not expected that the development of private trout culture will ever approach the magnitude of the development of the warm-water fishes, as the environmental requirements of trout are much more exacting. Suitable water supplies are difficult to locate, and the investment that is required to establish such a business is prohibitive for many individuals who might otherwise enter into such an activity.

It may be pointed out that private trout businesses are not conducted primarily as hobbies, as is sometimes thought, but as livelihoods. Furthermore, private trout culture in the West is big business and promises continued growth.

Methodology

Lists of all persons and organizations holding State permits for fish breeding were obtained from the various States that were covered in the survey. The "fish-breeder" permit is issued for the culture of any one or more of several kinds of fishes, such as minnows for bait, warm-water game fish, or trout. Questionnaires were sent to virtually all of the permittees (table 1). A follow-up questionnaire that was sent to about one-third of the operators who did not respond to the first request for information produced negligible results. This is not surprising, for many operators are naturally sensitive about divulging the personal details of their businesses--and the questionnaire asked for information about the financial investment and income.

However, 29.3 percent (185) of the 628 questionnaires were returned in various stages of completion. Because there was no means of determining how nearly random this sample was, it was decided to report the findings only, with no speculation as to how accurately the sample represented the entire group of fish breeders. The data presented and conclusions drawn are therefore based on the sample of 185 returns unless otherwise indicated.

About 74.6 percent (138) of the returns were from permittees who were handling trout either exclusively or along with other fishes (table 2). Breeders who were handling warm-water fishes such as bass,

TABLE 1.--Number of permittees and returns of questionnaires

State	fish-breeder permittees (1952)[1]	Number of questionnaires	
		Mailed[2]	Completed and returned
Colo.	325	297	56
Calif.	150	145	58
Wash.	57	56	23
Utah	38	37	7
Idaho	38	36	18
Oreg.	27	27	8
Mont.	19	19	12
Wyo.	8	8	2
Nev.	3	3	1
Totals	665	628	185

[1] Includes warm-water fish breeders as well as trout breeders.

[2] Differences between these figures and those in the first column are due to duplications of names on some lists and removal of some names on the lists between time of receipt of the lists and the mailing of the questionnaires.

bluegill, crappie, and catfish accounted for 13.5 percent of the returns. Two of these operators reared "minnows" for sale as bait. The returns from 8.6 percent of the permittees indicated that they were not then actually engaged in any fish business even though they possessed permits. From the remainder of the returns, nothing of the nature of the operations involved could be determined. The following discussion is based on the returns from the 138 permittees who dealt in trout.

Type of Trout Businesses

The most popular single type of operation among the trout culturists was the "u-catch-em" or "catch-out" pond. Here the usual physical arrangement is a small pond or two with a minimal water supply, located near a large residential area or adjacent to a well-traveled highway. The operator periodically stocks his ponds with catchable-sized trout from nearby trout farms, and these trout are sold to the public on a "pay-for-what-you-catch" basis. Very often this kind of business is conducted in conjunction with the rearing of trout for other purposes. However, it should not be thought, necessarily, that the "u-catch-em" pond in these operations is merely a sideline, as occasionally it is the most lucrative aspect of the business. In Colorado, particularly, many fishing ponds are developed and maintained for an organization of fishermen or merely for the private use of a few individuals.

More than one-third of the businesses comprised a fish hatchery, outside rearing ponds, plus a public fishing pond. Many operations of this kind depended on

TABLE 2.--Kind and status of fish-cultural operations reported

State	Hatchery for egg production only	Hatchery plus rearing ponds	Fishing ponds only	Hatchery, rearing ponds plus fishing ponds	Rearing ponds plus fishing ponds	Warm-water fish only	Kind questionable	Out of business
Colo.	1	8	14	10	9	7	1	6
Calif.	-	2	10	12	9	16	4	5
Wash.	1	1	5	12	2	1	-	1
Utah	-	1	-	2	-	1	1	2
Idaho	-	7	4	2	3	-	-	2
Oreg.	-	1	1	3	3	-	-	-
Mont.	-	3	2	6	1	-	-	-
Wyo.	-	-	-	2	-	-	-	-
Nev.	-	1	-	-	-	-	-	-
Totals	2	24	36	49	27	25	6	16

a few large hatcheries for their initial stock of eggs, from which all or part of their ultimate fish production came. For example, virtually all trout reared in private operations in California originate from eggs obtained from large hatcheries in Montana, Idaho, and Utah. Few operators found it profitable to maintain their own brood stock. A few stations produced eggs only for sale.

Status of Ownership and Length of Time in Business

As would be expected, most businesses were owned by a single individual. However, in numerous businesses, particularly where the size of the operation was large, the ownership was in the hands of partners or a corporation.

In California the trout-culture movement apparently is developing rapidly now but, when compared to the development in Colorado, was generally slow in getting under way. Thus, 80 percent of the existing trout businesses in California (as reported) were established in the 5 years just previous to the time of this survey, whereas in Colorado only 27.8 percent were established in the same period. In California only 6.7 percent of the operations were more than 10 years old, but in Colorado 58.3 percent were older than that. From all trout enterprise returns, 51.4 percent of the operations were begun in the previous 5 years (table 3).

Investment and Income

An investment of $500 to $1,620,000 each in the establishment and development of their businesses was reported by 112 dealers. The total amount actually reported was $6,364,200. More than half

TABLE 3.--Number of years in trout business

State	Number of trout businesses in operation, by-- Years: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Colorado	-	1	2	3	4	2	2	-	-	1	-	3	1	1	1
California	5	7	5	4	3	3	-	-	-	1	-	-	-	-	-
Washington	3	4	2	-	3	-	3	2	1	1	-	-	-	-	1
Utah	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Idaho	-	1	3	2	1	3	1	1	-	-	-	-	-	-	-
Oregon	2	1	1	-	-	1	-	-	-	-	-	1	-	-	-
Montana	-	1	-	1	2	1	2	-	-	1	-	1	-	-	-
Wyoming	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Nevada	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Totals	10	15	13	10	16	10	9	3	1	4	-	5	1	1	2

State	Number of trout businesses in operation, by-- Years: 16	17	18	19	20	21	23	24	25	30	31	32	40	43
Colorado	-	-	1	-	4	-	1	-	2	4	1	-	2	-
California	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Washington	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Utah	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Idaho	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Oregon	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Montana	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Wyoming	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nevada	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	-	-	2	-	6	-	2	1	5	4	1	1	2	1

of the individual expenditures were in excess of $10,000. Four operators had spent more than $200,000 each (table 4). The average expenditure was about $56,823. The investments were made for land, buildings, equipment, and presumably in most cases for other improvements directly concerned with their fish businesses.

Gross income was reported by 75 dealers. The range of income was from $50 to $300,000. The mean gross income was approximately $29,705. About 50 percent of the incomes were in excess of $10,000. Thirteen dealers grossed more than $50,000 yearly.

TABLE 4.--Reported investment and gross income

State	Total investment	Number of replies	Gross income	Number of replies
Colo.	$3,206,500	28	$ 379,550	19
Calif.	855,500	27	612,000	15
Wash.	720,800	19	197,584	13
Utah	255,000	3	188,800	3
Idaho	766,500	14	678,200	13
Oreg.	250,900	8	35,000	4
Mont.	269,000	12	126,750	7
Wyo.	40,000	1	10,000	1
Nev.	-	-	-	-
Totals	$6,364,200	112	$2,227,884	75

Egg and Trout Production

Forty-two fish hatcheries reported a yearly production of 97,672,500 trout eggs of all species (table 5). A very limited production of trout eggs came from the States of California, Nevada, Oregon, and Wyoming. The States of Colorado, Utah, Idaho, and Montana--where excellent supplies of good water are available--were responsible for about two-thirds of all production. The number actually produced in Idaho, according to information obtained from sources other than this questionnaire, is nearer 50,000,000 than the 24,200,000 reported here. About two-thirds of all the eggs were obtained from rainbow trout.

Sixty-nine dealers marketed 3,374,000 trout, mainly rainbow, that were under 6 inches in length and 9,169,300 that were over 6 inches. This production was from eggs produced from brood stock maintained by the dealer or from eggs purchased by the dealer, rather than from small fish that had been purchased and reared to a larger size or from fish of catchable size purchased and sold by "catch-out" pondowners. The trout produced were sold mainly as fingerlings for lake stocking, as catchables for fishing ponds, and in the marketable (8- to 12-inch sizes) for restaurants, resorts, and frozen food stores. In several instances the bulk of the trout produced here were marketed to numerous small "catch-out" ponds.

Important General Problems

Trout dealers used springs, streams, wells, and storage basins as sources of water. There was often a shortage of water, and this limited production. There were several reports of legal difficulties over water rights.

Although the method of determining cost is not known, $0.575 per pound was reported by 20 operators to be the average cost of producing trout to the catchable size. There were reports of difficulty in obtaining sufficient quantities of inexpensive fish foods.

There are several regional and State organizations of private trout culturists in the West. Very recently, a national association was formed. Some of these groups are very active in promoting favorable legislation, which may be their principal reason for existence. The importation of inexpensive frozen trout from Scandinavian countries and Japan has been a matter of considerable concern, as trout may be produced in these areas, processed, and shipped to and sold in this country at prices that compete very favorably with prices of fish produced here.

The writer was almost overwhelmed with requests--most of them were made

TABLE 5.--Reported production of eggs and trout

State	Egg production				Number of replies
	Rainbow	Eastern brook	Cutthroat	Other	
Colorado	6,412,500	3,020,000	500,000	1/ 100,000	13
California	310,000	10,000	-	-	2
Washington	13,850,000	500,000	100,000	-	13
Utah	13,000,000	-	-	-	2
Idaho	24,200,000	-	-	-	2
Oregon	200,000	-	-	2/ 3,000,000	1
Montana	14,270,000	14,050,000	750,000	1/ 3,200,000	8
Wyoming	-	200,000	-	-	1
Nevada	-	-	-	-	-
Totals	72,242,500	17,780,000	1,350,000	6,300,000	42

State	Under 6-inch fish production				Number of replies
	Rainbow	Eastern brook	Cutthroat	Other	
Colorado	1,690,000	160,000	-	-	7
California	460,000	-	-	-	4
Washington	355,000	10,000	10,000	-	7
Utah	2,000	-	-	-	1
Idaho	-	-	-	-	-
Oregon	2,000	-	-	-	1
Montana	350,000	25,000	5,000	1/ 5,000	2
Wyoming	-	-	-	-	-
Nevada	300,000	-	-	-	1
Totals	3,159,000	195,000	15,000	1/ 5,000	23

State	Over 6-inch fish production				Number of replies
	Rainbow	Eastern brook	Cutthroat	Other	
Colorado	1,031,000	-	-	-	11
California	1,902,000	10,000	-	-	6
Washington	2,440,500	1,000	-	-	12
Utah	622,000	-	-	-	3
Idaho	2,710,000	-	-	-	8
Oregon	-	-	-	-	-
Montana	126,000	10,800	5,000	1/ 5,000	4
Wyoming	-	6,000	-	-	1
Nevada	300,000	-	-	-	1
Totals	9,131,500	27,800	5,000	1/ 5,000	46

1/ Brown trout.
2/ Atlantic salmon and lake trout.

by new operators--for such information as how to culture trout, how to detect and treat diseases and parasites, and where to obtain eggs and fish. A number of persons who apparently were without previous experience had already begun

operations and had encountered problems of one kind or another for which they had no solution. Others indicated that they would expand their operations if some of their more serious difficulties could be overcome.

It should be observed that in the West there is something of a fad for trout culture, especially of the kind that produces fishing. The contribution of these operations to the catch of all trout in the West is unquestionably very significant. The dissemination of information by, and the guidance of, State and Federal agencies could stimulate increased private investment in trout management in the West.

ELECTRICAL DIVERSION WEIR PROVES PRACTICABLE AT ENTIAT

An electrical diversion weir that the U. S. Fish and Wildlife Service installed on an experimental basis on the Entiat River in Washington during 1953 has made it possible to divert a sufficient number of the adult chinook salmon into holding ponds for spawning.

Patterned after the installations made for the control of the sea lamprey in the Great Lakes, the electrical diversion weir placed in the Entiat River consists of 50 electrodes (pipe, 1-1/2 inches) that are suspended vertically at 3-foot intervals at an angle across the stream. A ground line (pipe, 1-1/2 inches) has been laid 15 feet below the electrodes, following the bottom contour of the stream and parallel to the line of electrodes. The electrical field is activated by 110-volt, 60-cycle alternating current.

Roger E. Burrows, fishery research biologist stationed at the Salmon-Cultural Laboratory at Entiat, reports that the new diversion weir has provided an adequate barrier to the upstream migration of fish during high- and low-water stages of the river.

"Chinook salmon were diverted into the holding ponds much more readily by the electrical barrier than by the conventional picket weir," writes Mr. Burrows. "The longest time a recognizable fish fought the barrier before entering the ladder was 2 days. ... Blueback salmon were more reluctant to ascend the fish ladder and enter the holding ponds. Schools of 50 or more fish were observed to collect in a pool area about 200 feet below the diversion. These fish entered the ponds well ahead of their spawning time ... A total of 46 steelhead were diverted into the holding ponds. Of this group, 39 were seined or fished out and liberated above the weir and 7 males died in the ponds because they escaped capture. ... An estimated 500 suckers spawned in the ponds. Surprisingly enough, the suckers were successful in making their escape through the V's and returned to the river. A large number of whitefish, possibly 300 to 400, entered the ponds during the spring. Some of these fish were liberated during the seining operations for steelhead, but at least half of these fish remained in the holding ponds throughout the summer and are still in the ponds. Very few trout other than large Dolly Varden trout were diverted into the ponds. The majority of this species entered the trap along with the salmon and were liberated in the river above the weir."

While the electrical diversion weir is in operation, fish that enter the field are ordinarily diverted before they pass the ground line or after they have progressed about 2 feet over the ground line. The location of the ground line, with reference to stream bottom and distance from the electrodes, has been established by tests to determine effectiveness in diverting upstream migrants without injury.

The weir will be used only to get fish for the spawn-taking operations at the fish-cultural station at Entiat. In accordance with the Fish and Wildlife Service's policy of utilizing any available natural spawning areas, a significant portion of the run will be permitted to escape.

A COMPARISON OF HATCHERY DIETS AND NATURAL FOOD

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MOST OF THE INGREDIENTS OF DIETS fed to hatchery trout are foreign in the sense that the fish would seldom receive them in the natural environment. The composition of hatchery diets is based largely upon the results of feeding trials, and these usually are judged on the basis of growth, mortality, conversion, and the cost of production. In recent years definite nutritional deficiencies have been recognized, and supplements are added to the diet now to prevent the appearance of the known nutritional disorders. In formulating diets for hatchery fish, little or no attention has been given to the natural food of trout.

Embody (1924) has stated that it should be assumed that the proportion of nutrients occurring in natural foods would be the best to duplicate in our hatchery diets. Since that time, little has been done to test the validity of Embody's statement. Several authors have published somewhat extensive results of general analyses upon the natural food of trout (Birge and Juday 1922, Geng 1925, Mann 1935). Embody (1924) has reworked the data of Birge and Juday (1922), and Schaeperclaus (1933) has summarized the data of Geng (1925) in order to show standards that should be followed if hatchery foods are to be compounded in terms of the basic elements of natural foods (fats, proteins, ash, and carbohydrates). However, general analyses, although of great importance, will not permit an evaluation of diets in terms of the trace factors of foods (vitamins and minerals). Very little work has been done along these lines, though Kobayashi (1951) has reported the thiamine content of 100 insects and Vinogradov (1940) has determined the mineral content of plankton organisms.

Probably one of the reasons for this lack of study of natural food is the general belief that hatchery diets are more efficiently converted into fish flesh than are the natural foods of trout. A review of the literature fails, in general, to support this contention. Hatchery foods now in use will convert at a rate of about 3.0 pounds of food per pound of fish. Values for natural foods have been found that range from 2.3 to 7.1. In almost every instance where the higher values have been reported, underfeeding of the fish is evident in the experimental design.

Surber (1935) has reported a conversion of 6.6 pounds of Gammarus per pound of trout; Pentelow (1939), a conversion of 5.0; and Schaeperclaus (1933), a conversion of 3.9. Thus the literature shows a variety of results from experiments with the same organism. With reference to other organisms, it should be noted that Schaeperclaus (1933) has found that it requires 4.4 pounds of Chironomus to produce 1 pound of trout; Cornelius (1933), 2.3 pounds of trout (cannibalism); and the Cortland workers (not published), 7.1 pounds of the maggot of the housefly.

As the results cited above fail to show any great preference for hatchery foods over natural foods in terms of conversion,

it does seem expedient to test the validity of Embody's (1924) statement.

If hatchery diets are to be evaluated in terms of natural food, it is necessary to know both the general composition (fats, proteins, ash, and carbohydrates) and the composition in terms of the trace factors (minerals and vitamins). For the past 2 years, through the cooperation of several field workers, the Cortland laboratory has received samples of natural food to be used in analytical studies. This paper may be considered as a progress report on the work.

METHODS

General Analyses

Samples from the field were received in 95 percent alcohol. The alcohol was not changed after being placed over the specimens. The strong solution used precluded dilution of the alcohol by the body water and thus prevented spoilage during the storage period prior to the analysis. Each sample represented a pure culture of a single organism. In preparation for analysis, the samples were first heated on a water bath together with all of the preserving fluid. After the evaporation of the alcohol, the samples were placed in a vacuum oven and dried to constant weight. The samples were then ground in a mortar with a pestle. Protein was determined by the micro-Hengar method, fat was determined by continuous ether extraction, the iodine number of the fat was determined by the Hanus method, and the ash was determined by means of a muffle furnace.

Mineral Analyses

The samples that were used for the general analyses were used also for the determination of three minerals--calcium, phosphorus, and magnesium. Calcium was determined by the method of Peters and Van Slyke (1931), phosphorus by an adaptation from Kitson and Mellon (1944), and magnesium by the method of Scott (1939).

Vitamin Assays

Samples used for the vitamin assays were received in a frozen state, wrapped in waxed paper with an outer layer of aluminum foil. They remained frozen until they were used for analyses. Four of the B-complex vitamins were determined here (riboflavin, niacin, biotin, and pantothenic acid). All determinations were made by means of microbiological assays as described previously (Phillips et al. 1946, 1947).

Results of the analyses are shown in tables 1 and 2, and the values shown are the average of triplicate determinations.

DISCUSSION

General Analyses

The results in table 1 illustrate a great variance in the chemical content of organisms. This variance has been reported by previous workers (Birge and Juday 1922, Geng 1925, Mann 1935). All of the organisms have come from environments of similar chemical nature, but there is no assurance that each of the groups of organisms is in a similar stage of its life cycle. Some of the variance may be due to a difference in the age of the animal used for analysis.

The average values given at the bottom of table 1 agree closely with similar average values determined from the literature. Values of 36 organisms assembled from the literature were found to be 82 percent water, 10.1 percent protein, 1.7 percent fat, and 2.7 percent ash.

The last line of table 1 gives the analysis of a standard hatchery diet. There is a great difference between the values of this hatchery diet and the average values for natural food. The hatchery diet contains about half as much water, more than twice as much protein, half again as much fat, and four times as much ash. The iodine number of the fat of the hatchery food is considerably lower than that of the natural organisms. If chemical content alone is considered, the conclusion is that hatchery foods are nutritionally superior

TABLE 1.--Chemical composition of some natural fish foods[1/]

Organism	Percentage of--			Iodine number fat	Percentage of--			
	Water	Protein	Fat		Ash	Calcium	Phosphorus	Magnesium
Ephemerida (Baetis)	87.2	8.2	1.6	106	1.0	0.054	0.148	0.011
Plecoptera (Pteronarcys)	72.5	15.8	6.1	133	1.9	0.094	0.204	0.033
Plecoptera (Acroneuria)	76.5	17.9	3.2	130	1.1	0.054	0.220	0.022
Trichoptera (Brachycentrus)	87.3	8.4	1.8	123	0.8	0.023	0.140	0.010
Diptera (Simulium)	86.5	9.0	0.7	131	2.3	0.114	0.114	0.030
Amphipoda (Gammarus)	87.5	6.4	0.8	119	2.7	0.266	0.114	0.028
Oligochaeta (Helodrilus)	77.8	14.8	1.4	131	2.0	0.097	0.131	0.019
Average values:	82.2	11.5	2.2	125	1.7	0.100	0.153	0.022
Chemical content of hatchery diet:[2/]	41.4	28.5	3.2	89	6.3	0.706	0.806	0.083

[1/] Gammarus collected from Hot Creek, Calif.; all others from Convict Creek, Calif.
[2/] Hatchery diet composed of 20 percent beef liver; 30 percent beef spleen; 12 percent each of fish meal, wheat middlings, cottonseed meal, and dried skim milk; 2 percent salt.

to natural foods. This assumption, however, must be re-evaluated in terms of conversion of natural food into fish flesh. When conversion is considered, the lower chemical content of natural foods points to a more efficient utilization of the materials from natural food than from the hatchery diet.

Mineral Analyses

The last three columns of table 1 show the calcium, phosphorus, and magnesium contents of the natural foods. The same variation described for the general analyses can be noted in the mineral content. This variation may be a reflection of the differences in the external skeleton of the various organisms as well as of possible differences that may be caused by stages in the life cycle of the animal.

The comparison between natural and hatchery foods (last two lines of table 1) again indicates that, from the chemist's standpoint, the hatchery diet should be considered superior to wild food. The hatchery diet is seven times richer in calcium, more than five times richer in phosphorus, and four times richer in magnesium.

Vitamin Assays

Table 2 is a summary of the vitamin content of six groups of insects. Because these were received in a frozen state, they were not a part of the population used in the other studies of this paper.

As in the previously described results, all of the forms show a wide variation in their content of the four vitamins. A comparison with hatchery foods (last two lines of table 2) shows that the average values for the vitamin content of the natural foods, except in the case of riboflavin, are well below the values that are shown for the hatchery diet. Again it may be concluded that, with reference to nutrition, the natural foods are inferior to the hatchery diet.

General

When all of the analytical results are taken into consideration, it may be concluded that, from the point of view of the nutritionist, the hatchery diet is apparently superior to the natural foods studied. In all but one instance (riboflavin), the chemical content of the hatchery diet is well above that of the natural foods. As, according to values in the literature, one should expect similar conversions into fish flesh from both types of food, it appears logical to believe that the natural food must offer something that is lacking in the present hatchery diets. This could involve many factors--the digestibility of the food, amino acid content of the protein, biological value of the protein, availability of the factors present, and any number of undetermined elements that are not included in this study.

In the streams there are foods that do have a chemical content similar to that of the hatchery diet (other fish, for example). However, it has been shown by a number of workers (Juday 1906, Clemens 1928, Needham 1930, Lord 1933) that the types of organisms listed in tables 1 and 2 form 90 to 99 percent of the food eaten by trout 6 inches or less in length. It therefore becomes apparent that the diet of wild fish during early growth is composed of organisms inferior (according to present nutritional standards) to the hatchery diets, and yet the fish grow with an efficiency (based on conversion) that is similar to that found in the hatcheries. This would appear to warrant the making of additional studies along the lines of conversion of natural food into fish flesh, as well as studies on the various nutritional factors in natural food organisms.

TABLE 2.--Vitamin content of some natural fish foods

Organism	Micrograms per gram of wet tissue			
	Riboflavin	Biotin	Pantothenic acid	Niacin
Odonata (Anisoptera)	33.5	0.207	17.3	27.8
Diptera (Tipula)	9.2	0.151	11.2	10.3
Plecoptera	10.9	0.383	10.9	28.2
Ephemerida (Hexagenia)	11.9	0.266	18.5	28.0
Ephemerida (Chirotenetes)	2.0	0.490	19.9	35.9
Trichoptera	6.1	0.437	20.1	38.1
Average values:	12.3	0.322	16.3	28.1
Vitamin content of hatchery diet: 1/	13.9	0.520	22.6	42.8

1/ Hatchery diet is composed of 20 percent beef liver; 30 percent beef spleen; 12 percent each of fish meal, wheat middlings, cottonseed meal, and dried skim milk; and 2 percent salt.

ACKNOWLEDGMENT

The writers wish to acknowledge their indebtedness to Floyd E. Lovelace and Henry A. Podoliak of the Fish and Wildlife Service for the mineral analyses, and to William C. Beckman of the Fish and Wildlife Service and Shelby Gerking of the University of Indiana for the frozen specimens used in the vitamin assays.

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A FIELD METHOD OF ESTIMATING SOLUBLE INORGANIC PHOSPHATE IN NATURAL WATERS

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DETERMINATION OF PHOSPHATE PHOSPHORUS in ponds and streams is of prime importance to the aquatic biologist because this constituent is frequently the limiting factor in the productivity of plant growth, which in turn determines the fish yield of a given water area. According to Moyle (1945, 1949), the optimum phosphorus concentration for greatest fish yield is in the range from 0.1 to 0.2 part per million. As most Connecticut ponds have concentrations much lower than this (Conn. Geol. and Nat. Hist. Surv., 1942), any method for analysis of phosphorus in these waters must be applicable to a concentration range of about 0.01 to 0.2 part per million. All methods for phosphate determination which have been described to date have about 0.1 part per million phosphorus as a lower concentration limit and therefore are not suitable for use in the analysis of these waters. This investigation was undertaken to develop a rapid and easy method that could be used either in the field or in the laboratory to determine phosphorus in the range of concentrations found in natural waters.

The most widely used and best-known method for determining traces of phosphate is the molybdenum blue method, a colorimetric method which involves the reduction of phosphomolybdic acid to a blue product by any of a number of reducing agents. Stannous chloride has been reported (Woods and Mellon 1941) to be superior to others which have been suggested and it has been used in the present investigation.

A survey of the literature revealed that this method is the most sensitive (i.e., will detect the smallest concentration of phosphorus) method yet described. From this standpoint the method seemed most suitable for use in an effort to achieve a determination of phosphorus in the low concentration ranges.

For adaptation of the method to low concentration ranges, tall-form Nessler tubes of 50-milliliter capacity are essential as the viewing tubes. Under these conditions a sufficient column of solution is obtained to give easily visible color intensity for phosphate concentrations as low as 10 parts per billion phosphorus.

In order to evaluate the concentration of the unknown phosphate solution, either a spectrophotometric method or a visual comparison of the color with color standards is necessary. For use as a field test, a visual method of comparison with permanent color standards is essential. Solutions containing known amounts of phosphate treated to give the molybdenum blue color cannot be used as color standards because the color of these solutions is not permanent. A definite decrease in color intensity is noticed even after 15 minutes. Other color standards, such as

This investigation was supported by Federal Aid to Fish Restoration funds under Dingell-Johnson Project No. F-3-R.

Indigo carmine (Florentin 1921), reduced molybdate (Meyer 1930), and mixtures of copper and cobalt salts (Denigès 1930), have been proposed as permanent color standards. These standards have been criticized, however, as not matching the color of the molybdenum blue very well (Woods and Mellon 1941). In the course of this investigation, there were developed very suitable color standards which have proved very stable. Through the use of these permanent color standards, the field determination of phosphate is easily accomplished.

PREPARATION OF COLOR STANDARDS

Reagents

1. Copper sulfate solution: Dissolve 34.6 grams of reagent-grade copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$) in 1 liter of distilled water.

2. Bromphenol blue solution: Dissolve 0.1 gram of bromphenol blue in 1 liter of distilled water.

3. Buffer solution: Dissolve 100 grams reagent-grade sodium acetate trihydrate ($NaC_2H_3O_2 \cdot 3H_2O$) and 65 milliliters of reagent-grade glacial acetic acid in distilled water, and make up to 1 liter with distilled water.

4. Standard phosphate solution (10 parts per million phosphorus): Dissolve 0.053 gram of carefully dried reagent-grade anhydrous trisodium phosphate (Na_3PO_4) in 1 liter of distilled water. The anhydrous salt can be obtained by drying the commercially available hydrated trisodium phosphate at 125° to 150° C. overnight.

As containers for the color standards, 1-ounce flat-bottomed glass vials (inside diameter, 20 millimeters) were chosen. Screw caps that ordinarily contained droppers were used as stoppers for the vials by removing the droppers, cutting thin Lucite circles, and placing them inside the caps. This made it possible for one to look through the solution along the axis of the sealed vial.

To prepare the standards, place the required amounts (table 1) of copper sulfate and bromphenol blue solutions in a vial and add the buffer solution to bring the volume up to 30 milliliters. Using 1 M sulfuric acid or 1 M sodium hydroxide, adjust the pH of the solution to 4.53 or as needed to obtain the proper hue.

To match exactly the permanent color standard solutions in hue and in intensity with the color obtained from the molybdenum blue tests for phosphate, a comparison of these standards with solutions containing known amounts of phosphate is necessary. As an example, to prepare the permanent color standard for 20 parts per billion phosphorus, take the volume of standard phosphate listed in table 1 as corresponding to 20 parts per billion and treat as in the procedure below. After preparing the approximate color standard as listed above, adjust the hue of the permanent color standard by varying the pH, and adjust the intensity by varying the

TABLE 1.--Volumes of copper sulfate (0.00883 grams/milliliter) and bromphenol blue (0.010 percent) needed to prepare color standards

Concentration of phosphorus (p.p.b.)	Copper sulfate (ml.)	Bromphenol blue (ml.)	Standard phosphate[1] (ml.)
10	0.40	0.085	0.05
20	0.70	0.150	0.10
30	0.96	0.210	0.15
40	1.17	0.330	0.20
50	1.40	0.400	0.25
60	1.60	0.500	0.30
70	1.79	0.620	0.35
80	1.95	0.750	0.40
90	2.17	0.900	0.45
100	2.40	1.000	0.50
120	2.82	1.145	0.60
150	3.40	1.540	0.75

[1] Volume of standard phosphate solution (10 p.p.m.) needed in 50 ml. to prepare the dilutions listed in first column.

volume until the best visual match has been obtained. It is imperative that this matching be done with the comparator or under conditions exactly the same as those that will be used in the test. After matching, the vial can be sealed and is ready for use. Such a procedure is needed to prepare the color standards over the range of concentrations that is of interest. With a little experience, the technique of matching the color becomes easy.

The stability of these permanent color standards was demonstrated by spectrophotometric determinations of the transmittancy of a sample of the color standard during the period when it was allowed to remain in an east window and receive considerable direct morning sunlight. After 24 days of such treatment, the percentage transmittance values of the sample over the visible region were constant within experimental error.

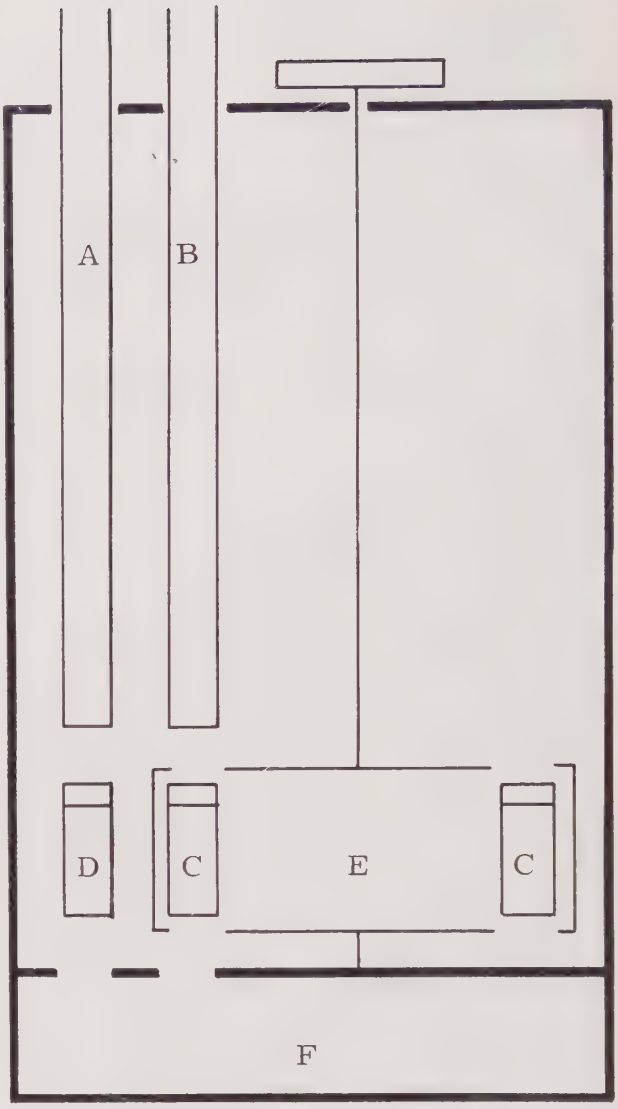
CONSTRUCTION OF THE COMPARATOR

A special device for comparison of the solutions was desirable so that the test could be performed easily without the necessity to handle loose containers, and so that all necessary equipment could be handled and carried easily.

More important, perhaps, was the necessity to design a comparator such that the test could be performed in a manner that would prevent interference from the natural color of the pond water. To do this, it is necessary to assume that the natural color of the pond water and the color of the molybdenum blue solution are additive, and that no interaction between them occurs. Then, by including in the optical path through the color standard the same amount of untreated pond water as is used in the test, the optical paths become the same and the effect of colored water is nullified.

The comparator which was designed to meet these requirements is shown in the figure. The comparator is a wooden box having near the bottom a circular holder that will hold 10 to 12 color standards.

(Drawing, right, courtesy of the authors)



Comparator used in these tests.

A, B--Matched Nessler tubes; solution depth, about 8.75 inches. Tube A, treated with stannous chloride to develop molybdenum blue color. Tube B, untreated sample of water being tested.

C--Vials (1-ounce) of color standard solutions. Medicine droppers in plastic screw caps of vials are replaced by thin Lucite windows.

D--Vial (as used for color standards) containing distilled water.

E--Rotating cylindrical holder for color standards.

F--Light-diffusing chamber. Interior is painted white; hinged front panel is adjustable at desired angle to direct light into the chamber.

This holder can be turned around on its axis by means of a knurled knob on the top of the box. The color standards can thus be rotated and successively brought into optical alignment underneath a Nessler tube which, during the actual test, will contain untreated pond water. Close to this Nessler tube is another Nessler tube that will contain the pond water on which the test is performed. Below this second Nessler tube is a vial that is exactly like those containing the color standards but contains only distilled water. This vial may be permanently mounted. The box has a false bottom with a door to the lower chamber which opens from the top. The inside of this chamber is painted white, and by adjustment of the door opening it is possible to obtain in the chamber and thus through the Nessler tubes sufficient light so that the color of the solutions can be compared easily. The upper part of the comparator box has a door that opens from the side. Inside, near the top, is a shelf so constructed that the necessary reagents for the test can be stored conveniently. To prevent spillage of these reagents when the box is being carried, each one is held tightly in place with a metal band.

PROCEDURE

Reagents

1. Acid molybdate solution: Dilute 298 milliliters of concentrated reagent-grade sulfuric acid (specific gravity, 1.84) to 1 liter with distilled water. Dissolve in this material 25 grams of the reagent-grade ammonium molybdate ($NH_4Mo_7O_{24} \cdot 4H_2O$). Store in a brown bottle.

2. Stannous chloride solution: Dissolve 2.5 grams of reagent-grade stannous chloride dihydrate ($SnCl_2 \cdot 2H_2O$) in 10 milliliters of concentrated reagent-grade hydrochloric acid (specific gravity, 1.19) and dilute to 100 milliliters with distilled water. If the stannous chloride does not dissolve in the hydrochloric acid, it should be discarded and fresh material obtained and used. Keep the solution tightly stoppered. Discard and prepare a new solution after 1 month.

If the water to be tested contains any suspended matter, it must be filtered before the test is performed.

Place 2.0 milliliters of acid molybdate solution in each of two matched Nessler tubes of 50-milliliter capacity. Add the filtered pond water to the acid molybdate solution in the tubes, filling the tubes exactly to the mark. (The solution must be about 8 inches in depth when the tube is filled to the mark.) Stopper the tubes with clean corks or rubber stoppers and mix by inverting two or three times. Add 2 drops (approximately 0.1 milliliter) of the stannous chloride solution to one of the tubes, mix well, and place in the comparator. Use the other tube for a blank and place in the optical path with the color standard. Using the knob, find the standard which best matches the unknown solution. It will be necessary to wait 4 or 5 minutes before making the final comparison, as the molybdenum blue color sometimes develops slowly. After 10 to 15 minutes it will begin to fade noticeably; so the final comparison should be made between 5 and 10 minutes after the addition of the stannous chloride solution.

RESULTS

The accuracy of the method was tested in the laboratory on synthetic samples of phosphate, and values which agreed to within 5 parts per billion could be obtained with them. In order to check the method on actual pond water, several samples of water from ponds throughout the State were tested. Table 2 shows a few of the results obtained.

For sample No. 2 in table 2, exactly 1 liter of the filtered water of Peat Works Pond was evaporated to approximately 35 milliliters and refiltered, acid molybdate and stannous chloride were added, and the volume was made up to exactly 50 milliliters by the addition of distilled

TABLE 2.--Results of analysis of phosphate in pond waters

Sample number	Source	Method	Phosphorus concentration (p.p.b.)
1	Peat Works Pond	Use of comparator with permanent color standards	0 - 5
2	Peat Works Pond	Spectrophotometric[1/]	2.5
3	Swan Lake	Use of comparator with permanent color standards	5 - 10
4	Swan Lake plus 30 parts per billion added phosphorus	Use of comparator with permanent color standards	35 - 40

[1/] See text for method.

water. The color intensity (optical density) was then measured with a Model B Beckman Spectrophotometer. By comparison with a standard optical density-phosphorus concentration curve prepared by use of solutions of known phosphorus concentration, the optical density of this solution was found to correspond to a concentration of phosphorus of 50 parts per billion. As this solution was concentrated by evaporation from 1,000 to 50 milliliters, the concentration of phosphorus in the original water corresponds to 50/20 or 2.5 parts per billion, which compares very favorably with that found visually.

To check the method at higher concentrations, 30 parts per billion phosphorus was added to a sample of water from Swan Lake. The original water contained 5 to 10 parts per billion, whereas the sample with added phosphate contained 35 to 40 parts per billion. Tests performed on water from other ponds and lakes have given similar results and thus have indicated the reliability of this method for the determination of soluble phosphate in natural waters.

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A CHECK ON TWO METHODS OF ESTIMATING FARM FISHPOND POPULATIONS

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THE PRIMARY OBJECTIVE of this investigation was to compare the accuracy of estimates of fish populations obtained by use of two sampling techniques with the population figures derived from a total count of fish recovered after drainage of a pond.

The Upper Pond on the campus of the Virginia Polytechnic Institute at Blacksburg, Virginia, was chosen for the study area. This pond has an area of 2-1/2 acres, as determined by grid count on a compass intersection map. The pond has an average depth of 3.22 feet;[1] however, figure 1 shows that there are deeper channels along the southeastern bank and on each of the longer sides of the island. In December 1949 the pond was stocked with largemouth bass (Micropterus salmoides Lacepede) and bluegills (Lepomis macrochirus Rafinesque) at the ratio of 1,000 bluegills to 200 bass fingerlings per acre of water. No other fish were known to be in the pond at the time of restocking.

A 3/4-inch mesh seine, 135 feet long and 16 feet wide, was used to capture the fish for marking purposes. The size of the mesh limited the catch to fish larger than approximately 1-1/2 inches. The seine was pulled into the water by using a canoe and about 125 feet of rope; then the seine was hauled into shore, and all the

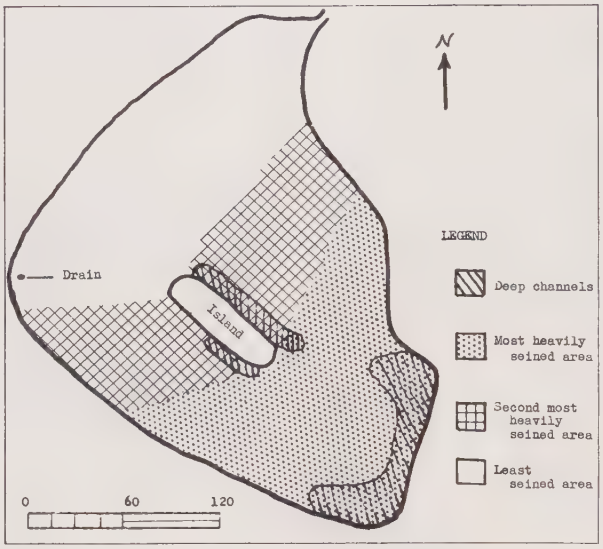

FIGURE 1.--Upper Pond, V.P.I. campus. (Illustrations courtesy of the author)

fish were removed. When the fish had been counted, both pectoral fins were clipped close to the base and then the fish were returned to the pond. A record of the number of original captures and recaptures of each species was kept for each pass with the seine.

When at least 20 percent of the catch were recaptures for 3 consecutive hauls, seining and marking were stopped and the pond was partially emptied by draining and pumping. When the water was low enough to permit the use of small seines--about 10 feet long and 5 feet wide with a 3/4-inch mesh--fish were removed from the pond

[1] Bowman, N. R. 3d. 1951: Report on survey of Upper Pond, V.P.I. campus, for weed control. Unpublished report.

TABLE 1.--Population data and estimates (by the Krumholz formula and by the Schumacher-Eschmeyer formula) for various species in the V.P.I. Upper Pond

Date	A Number of fish examined	Number of fish marked	B Number of marked fish in pond	Product A x B	Sum of products	Number of returns	C Sum of returns	Estimated Population Krumholz	Estimated Population Schumacher and Eschmeyer
Bluegills and pumpkinseeds									
Sept.									
18 1/	166	166	-	-	-	-	-	-	-
18	66	65	2/ 165	10,890	10,890	1	1	10,890	10,890
19 1/	80	76	230	18,400	29,290	4	5	5,585	5,556
19	155	147	306	47,430	76,720	8	13	5,901	5,814
22 1/	52	48	453	23,556	100,276	4	17	5,898	5,840
22	200	183	501	100,200	200,476	17	34	5,896	5,873
23 1/	26	23	684	17,784	218,260	3	37	5,872	5,880
23	201	160	2/ 706	141,906	360,166	41	78	4,617	4,319
24 1/	14	7	3/ 864	12,096	372,262	7	85	4,379	4,011
24	24	21	871	20,904	393,166	3	88	4,467	4,156
25	107	93	892	95,444	488,610	14	102	4,790	4,659
26	68	58	985	66,980	555,990	10	112	4,961	4,924
29 1/	20	13	1,043	20,960	576,550	7	119	4,845	4,753
29 4/	28	17	1,056	29,568	606,118	11	130	4,663	4,501
29	46	36	1,092	59,232	665,350	10	140	4,753	4,559
Largemouth bass									
Sept.									
18 1/	2	2	-	-	-	-	-	-	-
18	7	7	2	14	14	-	-	-	-
19 1/	3	3	9	27	41	-	-	-	-
19	4	4	12	48	89	-	-	-	-
22 1/	1	1	16	16	105	-	-	-	-
22	2	2	17	34	139	-	-	-	-
23 1/	1	1	19	19	158	-	-	-	-
23	5	5	20	100	258	-	-	-	-
25	2	2	25	50	308	-	-	-	-
26	4	3	27	108	416	1	1	416	304
29 1/	2	2	30	60	476	0	1	476	370
29	2	0	32	64	540	2	3	180	133

See footnotes at end of table.

TABLE 1.--Population data and estimates (by the Krumholz formula and by the Schumacher-Eschmeyer formula) for various species in the V.P.I. Upper Pond--Continued

Date	A Number of fish examined	Number of fish marked	B Number of marked fish in pond	Product A x B	Sum of products	Number of returns	C Sum of returns	Estimated Population Krumholz	Estimated Population Schumacher and Eschmeyer
			Golden shiners						
Sept.									
18	5	5	-	-	-	-	-	-	-
19	4	4	5	20	20	-	-	-	-
22	1	1	9	9	29	-	-	-	-
22[1/]	7	6	10	70	99	1	1	99	88
23	1	0	16	16	115	1	2	58	44
25	3	1	16	48	163	2	4	41	35
26	1	1	17	17	180	0	4	45	40
			White crappie						
Sept.									
19	2	2	-	-	-	-	-	-	-
22	1	0	2	2	2	1	1	2	2
23	1	0	2	2	4	1	2	2	2
26	1	0	2	2	6	1	3	2	2
29	1	0	2	2	8	1	4	2	2

[1/] Second pass made with seine.
[2/] 1 marked fish found dead.
[3/] 2 marked fish found dead.
[4/] Third pass made with seine.

and taken to a checking station. Here they were separated by species into marked and unmarked fish and were tabulated.

Formulas

Krumholz (1944) suggested the formula

$$P = SAB/SC$$

for estimating fishpond populations where P is the total population, S is summation, A is number of animals examined each day (or each pass of the seine), B is the number of marked fish in the study area, and C is the number of returns.

Schumacher and Eschmeyer (1943) used the formula

$$N = S\, n^2(m + u)/S(nm)$$

to determine the population of fishponds in which N is total population, S is summation, n is the number of marked fish in the pond, m is the number of recaptures in each sample, and u is the number of unmarked fish in each sample. Schumacher and Eschmeyer calculated the sampling variance, s^2, by the following formula in which k stands for the number of samples taken from the pond:

$$s^2 = \frac{1}{k-1}\left[S\left(\frac{m^2}{m+u}\right) - \frac{1}{N}S(nm)\right] .$$

The standard error of the Schumacher and Eschmeyer population estimate was computed with the formula

$$S.E. = \sqrt{N^2\frac{Ns^2}{S(nm)}} .$$

Population Estimates

Data and estimates of the fish populations appear in table 1. Two species of Lepomis were grouped together. Although 10 pumpkinseeds were marked, none were recaptured; so no population estimate could be made for them. Also, it was very difficult to distinguish between bluegills and pumpkinseeds when they were taken from the mud and slime resulting from drainage of the pond (see figure 2).

FIGURE 2.--Recovery of fish during pond drainage. Note bottom mud and slime, in which some fish were lost, and which may have been a source of error in separating the marked and unmarked fish.

(Photo by Gordon H. Brown.)

Table 1 also has data for largemouth bass, golden shiner (Notemigonus crysoleucas crysoleucas Mitchill), and white crappie (Pomoxis annularis Rafinesque). The shiners and crappies were not stocked in the pond but probably were placed there by well-meaning people after the pond was restocked in 1949.

Results

A comparison of estimated fish populations and counted fish populations is given in table 2. If it is assumed that the same percentages of marked and unmarked fish escaped during the counting process, the corrected population estimate for bluegills

TABLE 2.--A comparison of the estimated fish population and the counted fish population in the V.P.I. Upper Pond

Species	Number of marked fish in pond	Number of marked fish recovered in draining	Counted population	Estimated population (Krumholz)	Percent of deviation	Corrected estimate	Percent of deviation	Estimated population (Schumacher and Eschmeyer)	Standard error of the population estimate
Bluegill sunfish and pumpkinseed	1,128	985 (87.5%)	4,786	4,753	0.69	5,482	13.3	4,559	497
Largemouth bass	32	29 (90.6%)	221	180	18.55	244	47.0	133	64
Golden shiner	19	16 (84.3%)	33	45	36.40	39	11.3	40	15
White crappie	2	2 (100.0%)	2	2	00.00	-	-	2	0

and pumpkinseeds would be 4,786/0.873 or 5,482, which gives 13.3 percent deviation from the estimate arrived at by the Krumholz formula. (The percentages of deviation in table 2 were calculated in regard to the counted population.) Likewise, the bass population estimate would be corrected to 221/0.906 or 244, which gives a deviation of 47.0 percent.

Conclusion

Data in table 2 indicate that the methods of sampling used are reliable for populations as large as that of the bluegills in the pond. The writer believes that the low bass population and/or difficulty in catching bass with a seine caused the estimated bass population to have such a high percentage of deviation.

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MALNUTRITION AND WINTER MORTALITY

Fishery workers at the Convict Creek Experiment Station of the U. S. Fish and Wildlife Service recently held brown trout without food for 120 days in an attempt to distinguish between mortality resulting from malnutrition and winter mortality resulting from other causes.

Two groups of brown trout were exposed to the same water temperatures, the daily averages of which ranged from 32° to 35° F. For this experiment, however, one group of trout was held indoors in a hatchery trough, while the other group was exposed to normal winter stream conditions. Neither group was given any food in 120 days. At the conclusion of the test period, the mortality in the stream group was 17.7 percent and the mortality in the sheltered group was 9.3 percent. Many of the 120-day survivors were active and in good condition.

Reporting the test, Norman Reimers, chief of California-Nevada Inland Fishery Investigations, suggests that actual starvation may be a minor factor in overwinter losses.

"Differences in mortality between exposed and sheltered trout groups were not striking," concludes Mr. Reimers, "but indicate that icing and other physical factors may be more critical than lack of food."

This winter Mr. Reimers will repeat this test, and Dr. A. M. Phillips, Jr., of the Cortland (New York) Laboratory will do bioassays on all fish in the experiment.

Seven control structures maintained by the Great Lakes Fishery Investigations staff of the U. S. Fish and Wildlife Service on tributaries of northern Lake Michigan between March 19 and May 24, 1954, took 5,828 lampreys.

During the same period, 44 structures located on Lake Superior streams caught 1,949 lampreys. The take of lampreys in Lake Superior streams east of Marquette was generally larger than in the 1953 season. To the west of Marquette, only 6 of 28 streams yielded any sea lampreys, a circumstance suggesting that this parasite may not yet be firmly established in the central and western areas of the lake.

CHECK DAMS TO MAINTAIN TROUT STREAMS

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Whitney Park
Sabattis, New York

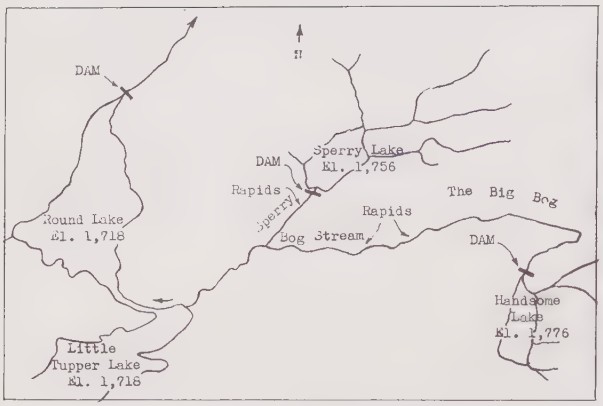
DID YOU EVER SIT ON THE BANK OF A TROUT STREAM IN MAY, watching the great volume of cold, clear water gliding swiftly between the banks, and imagine the number of good trout that must be lying in pockets all along such a magnificent piece of water--and then return to the same spot in August, only to be shocked by the realization that the shrunken stream did not carry enough water to harbor more than an occasional small trout? The truism, "a chain is no stronger than its weakest link," certainly applies to trout streams; and the weak link in most sizeable trout streams is the low summer volume and the high temperature that goes with it.

Many years ago I figured out to my own satisfaction how this problem could be solved, but not until I took over the management of natural resources on 96,000-acre Whitney Park 5 years ago did I have the requisite large "outdoor laboratory" and the means to put theory into practice. The principle is very simple: you merely hold some of the runoff in suitable basins when the streams are too high and release it gradually when the streams are too low.

As we had already done intensive improvement work on Bog Stream and its upper basin seemed well suited for the requisite seasonal storage of water, we built the first streamflow-augmenting structure on Sperry Pond, which drains into Bog Stream. Sperry Pond--122 acres with a drainage area of 5.5 square miles--is a beautiful natural body of water, and on its live green shoreline are about 20 giant white pines that were there when the first white man saw the pond. As an examination of the shoreline showed a fluctuation of about 1 foot between the maximum and minimum water levels in nature, we built our dam to impound a maximum of 2 feet above the summer low or 1 foot above the natural maximum, believing that the slight increase for short periods each year would not damage the shoreline. In the bottom center we set an 18-inch pipe regulated by a slide valve; on either side, at the 2-foot elevation, we had a spillway 12 feet wide.

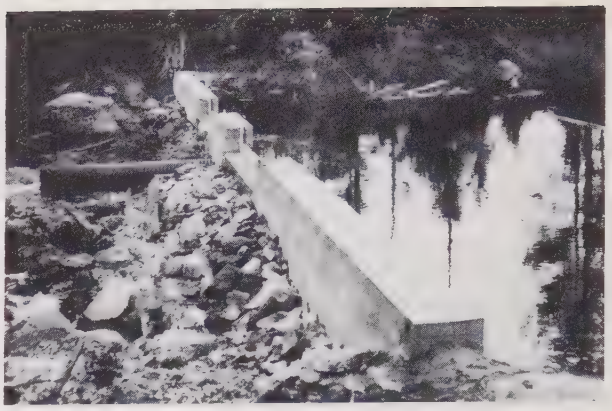
On paper, the plan worked as follows: The 2-foot head on Sperry's 122 acres of surface would impound 10,628,640 cubic feet of water. Assuming a 90-day drought, gradual release of the stored head over that period would add 615 gallons per minute (1.353 cubic feet per second) to the flow of the outlet. As the natural low-water flow when the dam was finished in August 1951 was 200 gallons per minute (a scant 0.5 cubic foot per second), the volume would be quadrupled with a total flow of 815 gallons per minute (nearly 2 cubic feet per second). No allowance was made for increase in evaporation from the uncounted increase in surface area, as the uncounted additional volume stored would more than offset any such loss.

Actually, the dam delivered considerably more water, for no one ever heard of 90 consecutive days in an Adirondack summer without a drop of rain. The flow has never been below 1,000 gallons per minute (2.25 cubic feet per second); and when the rains came in October 1952, we still had 15 inches of stored head--and couldn't get rid of it until the next spring! Now an auxiliary 18-inch pipe is left open from the time the fall rains start till we want to store water the following spring.



Sketch map of area.

(Illustrations courtesy of the author.)



Sperry Pond dam at low level, the valve open 3½ inches. Pipe, 12 feet, now cut to 6 feet.

The appreciable increase in size and number of trout in 1952 and 1953 indicates that fish in lower Bog Stream and Little Tupper Lake like the increased flow in Sperry Brook. Also, our trap records show that the trout have no difficulty in traveling up as well as down through the short pipe outlet.

In July 1953, we completed a similar dam on Handsome Pond, at the head of Bog Stream. Here, with a smaller watershed and a larger pond surface, release of the 2-foot stored head over the same hypothetical drought period multiplies the natural low-water flow by 6!

The third and largest unit in our program to date is the rebuilt Round Lake dam, completed in February 1954. Here, with a watershed of 66 square miles above the dam, we installed two 36-inch pipes and slide valves in the main outlet and two more of the same size under the flood spillway. The flow records over a 4-year period show a minimum of 3.25 and maximum of 845 cubic feet per second--a ratio of more than 250 to 1. With a surface area of 3,072 acres in Round Lake and connected Little Tupper, a 3-foot stored head (slightly less than has already been flooded by the old dam) released over the same 90-day period will add 51.8 cubic feet per second to the volume and multiply the natural low flow by 16! Actually, we should be able to maintain a minimum flow of 60 cubic feet per second, for again no rain has been figured during 90 days and the increased flow from Sperry and Handsome has not been included. From winter observations, I estimate that 60 cubic feet per second will be a perfect volume for the stream channel and anything over 100 cubic feet per second would be higher than desirable. With our four 36-inch valves and our auxiliary flood spillway, I believe we can keep the main outlet channel within these limits except when the ice goes out during the spring runoff.

With the low heads used here, the drop in temperature from a bottom outlet is, of course, negligible. Occasionally, when water goes over the spillways, the temperature of the pipe discharge registers as much as 1° less, but usually it is less than 0.5°. Any change is always on the cool side. Further, a well-filled brook tends to run cooler than a shriveled one.

At the Round Lake dam, the cooling effect of a bottom outlet should be slightly greater, as the bottoms of the pipes are 6 feet below the lake level at low water. The downstream ends are also submerged. Now that trout can enter the stream and return to the lake at will--as they could before there was a dam--it will be interesting to see whether fishing improves and approaches the excellence of predam days.

This year we expect to build two more structures on headwater ponds entering the head, or south end, of Little Tupper Lake and two or three low dams in the channel of Bog Stream. This may be only an earth-and-gravel bar across the channel, with open pipes in the bottom, or a sheet-piling dam 1 foot above the summer water level and open at the bottom. As the flow increases, the water will rise till it spills over the top, making a long, narrow impoundage of 1 foot or less within the banks of the stream.

Almost every watershed offers many opportunities to employ this check-dam principle. On the main inlet of Handsome Pond, a 7-foot beaver dam with a 100-yard mouth was once a hindrance in maintaining streamflow. We breached the dam, put an 18-inch pipe in the bottom of the breach, covered it even with the top of the dam, put an improvised wood slide on the upstream face of the pipe--and have since retarded freshets or released water as needed.

Such a program improves fishing not only on Whitney Park but even more on the State lands through which Bog River flows. Moreover, the program's benefits go far beyond fishing. If streams had a constant volume during the year, there would be no need of large storage dams for irrigation, power, navigation, or flood control. In approaching uniformity of streamflow, our program serves all these ends and many more of a public nature. If we think in terms of maintaining streamflow, our water-development programs will automatically take care of most of the flood and power needs, and the public effects will all be in the asset column.

BROWN TROUT ANESTHETIZED WITH ETHER FOR SPAWN-TAKING

The desirability of anesthetizing large brown trout with ether before making any attempt to strip these fish of eggs or milt has been reported by Leonard N. Allison, fish pathologist of the Michigan Institute for Fisheries Research, now stationed at the State fish hatchery at Grayling, Michigan.

"At the State fish hatchery at Paris, Michigan," writes Dr. Allison, "spawn-taking from the large brown trout was always followed by mortality among the brood stock. As these trout--weighing from 2 to 5 pounds--were very active and difficult to handle, it was believed that some of them might have received fatal injuries during the removal of their spawn. In an attempt to reduce this post-spawning mortality, therefore, it was decided to anesthetize the fish in etherized water before the stripping operation was begun.

"To make this test, the brood stock was divided into two groups. The brown trout in one group were anesthetized in water that contained 1 ounce of ether per gallon and then stripped; the brown trout in the other group, used as the control, were simply stripped in the usual manner.

"It was found that the anesthetized brown trout were much easier to handle and, because they were relaxed, were easily stripped. Furthermore, the post-spawning mortality amounted to only 5.6 percent in the group of fish that had been anesthetized, whereas this mortality was 35.4 percent in the control group."

Aside from the reduction in the post-spawning mortality, the test demonstrated the advisability of taking some precaution to keep the eggs and sperm from contact with the ether. Thus, in order to prevent the ether from causing any damage to eggs or sperm, any trout that are taken from etherized water should be rinsed in fresh water before they are stripped.

Dr. Allison has also reported some disadvantages to the use of ether:

"Objections to the use of ether are its inflammability and the necessity for frequent additions to keep an effective strength. Urethane, on the other hand, can be used effectively and does not have these objectionable qualities."

CHILLING THE EGGS OF THE LARGEMOUTH BASS

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EFFECTS OF LOW TEMPERATURES during the spawning season of the largemouth bass (Micropterus salmoides) were observed in an experiment on eggs taken from a pond at the Heart O'Hills State Fish Hatchery near Ingram, Kerr County, Texas.

The first phase of this experiment was an attempt to determine the effect of sudden chilling upon the eggs of largemouth bass. For this it was necessary to simulate as far as possible the sudden, late, relatively mild, spring northers which have plagued hatchery bass production in Texas for many years. These northers have, characteristically, occurred late in the bass spawning season and have apparently been the cause of hatching failures.

The second phase of this experiment was intended to simulate severe, relatively prolonged cold spells which cause hatching-pond temperatures to fall rapidly and to remain low for a comparatively longer period of time.

Collection Data

On March 10, 1953, at approximately 7:45 a.m., eggs were collected from a relatively large nest in Pond No. 39, a bass hatching pond, at the Heart O'Hills State Fish Hatchery.

These eggs were placed in a small enameled tray and washed thoroughly in pond water to remove any silt that might have been taken up with the sample of eggs. Next, the eggs were divided into 12 approximately equal portions and put into fine-mesh nylon bobbinet sacks. The sacks were then suspended about 4 inches from the bottoms of 12 fruit jars (2-quart capacity), and these jars were filled with water from the hatchery water supply. The bobbinet sacks were used so as to insure maximum aeration for the eggs in the jars, as no artificial aeration was to be supplied.

At the outset of the experiment, judging from the state of development of the embryos, it was estimated that the eggs were approximately 12 to 15 hours old.

There were some slight differences between the temperatures and pertinent chemical qualities of the water in Pond No. 39 and the water in the hatchery canal into which the eggs were placed. The water in Pond No. 39 registered a temperature of 58° F., a pH of 8.2, dissolved oxygen content of 9.8 p.p.m., and total alkalinity (bicarbonates) of 185 p.p.m.; whereas the water in the hatchery canal registered a temperature of 64° F., a pH of 7.9, dissolved oxygen content of 9.8 p.p.m., and total alkalinity (bicarbonates) of 250 p.p.m. However, constant checking of the development of the eggs, by microscopic examination, did not indicate that these differences were sufficient to matter in the experiment.

First Phase of Experiment

In the first phase of the experiment, four jars containing embryos were quickly chilled in a deep freeze so that their temperatures were, respectively, 5°, 10°, 15°, and 20° (F.) below pond temperature. (See table 1.) A fifth jar was not chilled but was kept as a control. After being

chilled, all five jars were placed on the concrete steps of the drain box in Pond No. 39. The jars were placed there in order to bring their temperatures back to pond water temperature and to insure that, other than the chilling, the eggs were subjected to conditions similar to those of the nest from which they had been taken.

During the first phase of the experiment, the embryos within the eggs subjected to the conditions already described were examined shortly after they were taken from the nest, 6 hours after being returned in jars to the pond, and again 15 hours later. It is of interest to note that at the time of collection these eggs had already developed a blastodermal cap. Six hours after they were returned to the pond in jars (approximately 8 hours after their first examination), the embryos in the control jar had developed a notochord. In the jars which had been chilled below pond temperature, however, the development of the embryos was retarded in proportion to the degree of chilling to which the eggs had been subjected.

Twenty-one hours after the eggs had been returned to the pond in jars, the embryos which had been held as controls not only had a completely formed notochord but also showed segmentation along their longitudinal axes. Some exhibited the beginnings of muscular activity. In addition, it was possible to detect an early stage of development of the eyes of the embryos.

In the embryos which had been chilled 5°, 10°, and 15° (F.) below pond temperature, development appeared nearly equal to that of the embryos held as controls. However, in the embryos which had been chilled 20° below pond temperature, retardation was noticeable in that development of the eyes was not equal to that of the embryos in other jars.

The five jars were removed from the pond the following day, March 11, 1953, at 8:30 a.m. They were then kept at room temperature several days. Development proceeded normally, and the majority of the embryos in all the jars hatched within 60 hours after the estimated time of fertilization of the eggs. The temperature of the water in the jars from the time they were removed from the pond until the eggs hatched ranged from 63° to 72° F.

TABLE 1.--Temperatures before and after chilling of embryos used in first phase of experiment[1/]

Jar number	Temperature before chilling (° F.)	Temperature after chilling (° F.)	Time required to chill (minutes)
1	64	53	79
2	64	48	113
3	64	43	159
4	64	38	178
5 (control)	64	64	0

1/ When the eggs were collected, at 7:45 a.m., March 10, 1953, pond temperature was 58° F. It slowly rose to 63° F. at 8:30 a.m., March 11, when the jars were finally removed from the pond.

This phase of the experiment demonstrates rather clearly that sudden, even extreme, lowering of the temperatures does not have directly adverse effects on bass eggs. It also demonstrates, however, that lowering of the temperature will retard development of the embryos and will prolong the period between the spawning and the hatching of the eggs.

Second Phase of Experiment

In the second phase of the experiment. two jars that contained eggs were chilled quickly in a deep freeze to 38° F., or approximately 20° below the temperature at which the eggs were collected from the pond. These jars were then placed in a refrigerator in order that they might be kept at a temperature considerably lower than that of the pond.

One of these two jars was kept in the refrigerator for approximately 5 hours 30 minutes. During this time the temperature in the jar never was allowed to rise above 42° F.

The second jar was kept under refrigeration for 14 hours 45 minutes. At the

end of this time, the temperature in the jar was 38° F. Thus this jar was kept at or near 20° below pond temperature for the entire period of refrigeration.

In both of these jars, retardation of the embryos was pronounced. When these embryos were compared with the embryos of the jars used as controls and kept at room temperature (72° F.), it was thought at first that the former were dead or dying. However, in a subsequent examination under the microscope, approximately 26 hours after the jar that was subjected to the most severe chilling had been allowed to return to room temperature, a very definite pulse and circulation of the blood throughout the embryo could be detected. Furthermore, all of these eggs hatched within 4 days after chilling.

This phase of the experiment indicated that even extremely severe chilling for 18 hours or more does not seriously harm bass eggs. In a small group of eggs that were chilled to 33° F., ice formed on the top of the jar and bobbinet sack. The yolk sacks of most of the eggs were ruptured. It was thought that these eggs, without question, would fail to develop; but even these eggs hatched. Eight days after the eggs were first collected, all fry were alive and apparently developing normally. This seems to be positive evidence that chilling, in itself, does not cause eggs to spoil but only retards their development.

Conclusions

The evidence seems to disprove the theory--held by many who are concerned with the pond culture of largemouth bass--that cold weather late in the spawning season is directly responsible for the loss of bass eggs while they are still in the nest.

Chilling as a result of lowered temperature of the pond water does not seem to be the direct cause for the spoiling of the eggs. However, another explanation for the loss of the eggs seems likely. It is probable that the male parent, whose function it is to guard and fan the nest during the egg stage of the young bass, deserts the nest with the lowering of the water temperature. The result of his action is that the eggs are left without aeration, and death follows.

The death of the eggs is probably due to several factors. As eggs in a nest are usually in large masses, only a small portion of any single egg is exposed to the water, and the entire exchange of respiratory gases must take place through this exposed portion of the egg membrane. This would lead to the accumulation of respiratory waste products, such as carbon dioxide, in the water surrounding the eggs; and death could occur from suffocation and lack of oxygen, since the parent bass is not there to circulate the water over the nest. Furthermore, the late cold spells are usually accompanied by strong winds. These winds increase wave action and roil the water, multiplying many times the amount of silt which could accumulate on the eggs. This accumulation of silt on the nest could also cause suffocation of the eggs.

The fact that older animals are most susceptible to adverse conditions is generally accepted. The fact that male bass leave the nest during late, cold northers has been witnessed at most hatcheries in the State.

Recommendations

Since cold spells late in spring have their detrimental effect in causing the male parent to desert the nest rather than in directly causing the eggs to spoil, it seems apparent that recommendations must deal with ways to keep the male bass on the nest or eliminate the function of the male bass after the eggs are fertilized.

It is possible that redesigning the hatchery ponds is indicated. Perhaps a pond should be built to provide less shallow water. This would force the bass to spawn in deeper water which, because of the buffer effect of the larger volume of water, would not be subject to such extremes in temperature fluctuation. This type of pond could have concrete sides to increase the water depth and to eliminate, to some extent, the roiling of the water through wave action against an earthen shoreline.

A less likely, though possible, solution might be found in devising a way to hatch bass eggs artificially. If bass eggs could be removed from the nest soon after fertilization and then could be placed in flowing water, it is within the realm of possibility that not only could production of bass fry be increased and spoilage be eliminated, but the hatching period might be somewhat reduced if the water was thermally controlled.

Undoubtedly, the heated hatchery pond for bass at the A. E. Wood State Fish Hatchery, near San Marcos, Hays County, Texas, has been one means of controlling the degree to which cold spells late in the spawning season have affected the production of bass fry. Details regarding this pond are contained in the May 1952 issue of Texas Game and Fish, published by the Texas Game and Fish Commission. This method of controlling the temperature in the hatching ponds should be investigated further.

Another possibility entails the construction of a refrigerated brood-bass holding pond, which would tend to retard the spawning of adult bass until the danger of northers was passed.

It is hoped that the experiments herein reported and the recommendations made will be of use in some way to those connected with the management of hatcheries producing largemouth bass, and that the work may stimulate further research along these lines.

FILLING LEAKS IN WOODEN BOATS

Flat-bottomed wooden boats that have rather large cracks (as much as 1/8 inch wide) in dried-out floor boards may be made ready for service with little difficulty, according to Donald F. Hansen, assistant aquatic biologist, Illinois Natural History Survey:

"It is best to have the boat resting on a boat trailer, or at least to have it elevated a foot or so from the ground. While water is running slowly into the boat from a hose, garden soil is poured or shoveled carefully over each leaking crack or over the general area of leaks (as determined by inspection of the under side of the boat) until all leaking stops. Usually this requires placing a layer of mud 1/4 to 1/2 inch deep over the cracks. Then, with the water 1 or 2 inches deep, the boat should be left to soak. Small additions of water may be necessary at 4-hour intervals."

"The fish in the aquariums have taken the place of a barometer for anglers coming to Guttenberg to fish in the Mississippi River," notes E. C. Saeugling, superintendent of the U. S. Fish-Cultural Station at Guttenberg, Iowa. "Before going to the river, the fishermen visit the aquariums to see whether the fish are feeding at the top or the bottom. An increasing number of fishermen are finding this a very successful method of determining whether they should fish deep or shallow."

The origin of Lake Baikal, in central Asia, has been traced by geologists to the Jurassic period, and the lake itself has been described as a vast aquarium of archaic forms. More than half of the known species of Gammarus, a primitive crustacean, are found in this fresh-water lake -- and no fewer than 148 species of this singular creature apparently occur nowhere else.

A NEW METHOD OF APPLYING INORGANIC FERTILIZER TO FARM FISHPONDS

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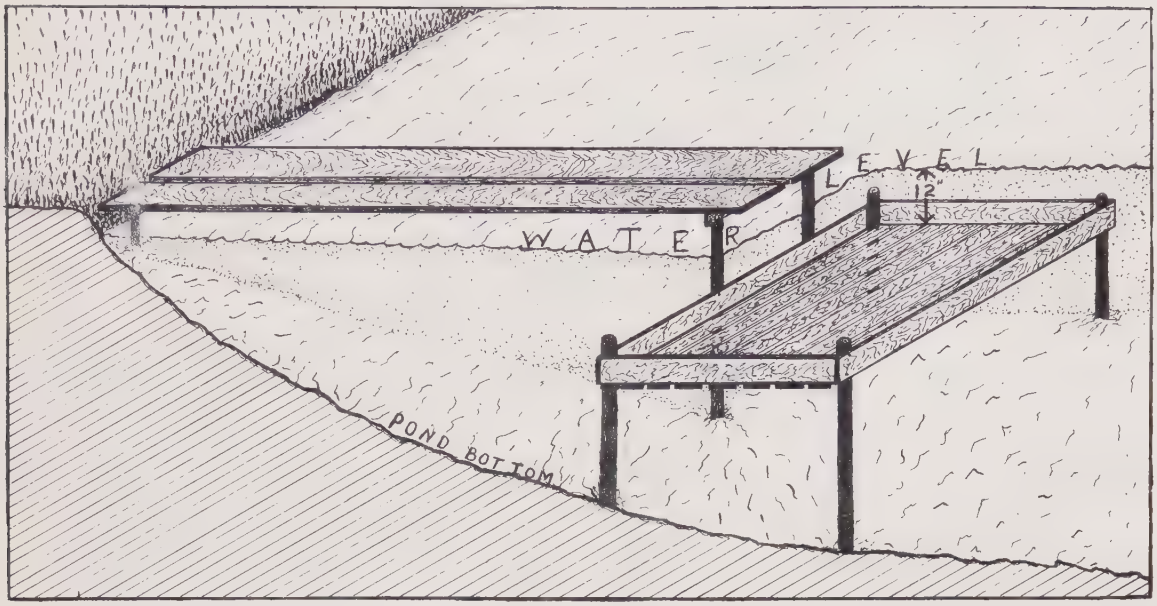
USE OF INORGANIC FERTILIZERS to increase fish production in farm fishponds is now practiced by thousands of pond-owners throughout the United States. The methods of applying the materials were originally described by Swingle and Smith (1939). They recommended that the fertilizer materials be broadcast from the bank over the shallow areas of small ponds, and that the materials be distributed over the shallow areas of larger ponds by the use of a boat and motor. These methods of application have produced good results but are time-consuming.

During the winter and early spring of 1953, experiments with nigrosine dye indicated that fertilization might be accomplished by using the water currents in ponds. While using this dye in attempts to control filamentous algae, it had been determined that if the material was placed in the water and the pond was then stirred with an outboard motor to obtain an even distribution of the dye, the color faded within 1 week. The idea of placing the dye in floats on the pond surface and allowing the material to distribute itself over the pond was tried. The experiments showed that the water currents, because of wind action in a pond, were sufficient to distribute the dye from one float uniformly, within a 24-hour period, throughout the surface waters in ponds 1 to 5 acres in size.

As such results were obtained with dye, it was reasoned that ponds could be fertilized by placing fertilizer on platforms under water and allowing the water currents to distribute it over the ponds. Five ponds, their sizes ranging from 1 to 26 acres, on the Farm Ponds Project at Auburn were fertilized by means of platforms during the spring and summer of 1953. Because all ponds operated by the Project are fertilized at the same rate per acre on a schedule prepared at the beginning of the year, a good comparison of the effectiveness of various methods of application could be made here. The platform method of application proved as efficient as either broadcasting fertilizer around the pond from the bank or applying the material with a boat and motor.

The platform method of applying fertilizer to a pond has several advantages over the previously recommended fertilization methods. First, the platform method is a much easier method of applying the fertilizer. Second, the fertilizer nutrients go into solution in the top waters of the pond and thus are more readily available to phytoplankton and less available to bottom growths of filamentous algae and rooted vegetation. Third, the nutrients go into solution over a longer period of time. Fourth, as the fertilizer elements go into solution in the top waters, there is less possibility that the phosphorus will be tied up on the pond bottom.

To use this method of application, the pondowner must provide a sufficient number of platforms on the pond to handle the required amount of fertilizer for each application. These platforms should be set 12 to 15 feet from the bank and located around the pond at points where the wave



A typical fertilizer platform: its relative position on the pond edge. (Courtesy the author.)

action will provide good distribution of the fertilizer elements over the pond surface. On small ponds, less than 5 acres in size, 1 well-located platform is usually sufficient. On larger ponds, 1 platform should be provided for each 8 to 10 surface acres.

The size of the platform is determined by the number of bags of fertilizer to be used in each application. Normally the surface area of platform needed to hold the quantity of fertilizer recommended for a 1-acre application is 3.5 square feet.

The platform is made of boards 1 to 2 inches thick and assembled in a manner similar to that shown in the figure. This platform is placed about 1 foot beneath the water surface and supported by posts driven into the pond bottom. Some type of substantial walkway from the bank to the platform should be provided so that the fertilizer may be added easily.

If the pond water level fluctuates considerably during the summer, it will be necessary either to place the platform far enough below the surface so that the water will cover it even during the driest period--or to fasten the platform to the posts with chains or by some other means that will allow it to be adjusted to the fluctuating water levels.

The recommendations as to kinds and amounts of fertilizer materials to be used with this platform method of fertilization are the same as for broadcasting from the bank or applying with boat and motor. To obtain high fish production, the application of fertilizer to the pond should be started while the waters are still cold. In southeastern United States, the first application of fertilizer should be made as soon after February 1 as conditions will permit. Additional applications are then made at regular intervals throughout the spring and summer to maintain so dense a growth of phytoplankton that an object cannot be seen 12 inches beneath the pond surface. As there are some slowly soluble materials in inorganic fertilizers, there will be times during cool weather when a considerable amount of the less soluble fertilizer materials may be on the platform--yet the pond may need another application of fertilizer to obtain the desired phytoplankton growth.

When fertilizer is to be applied by this method, unopened bags of fertilizer are laid flat on the platform floor and then the top-sides of the bags are ripped off.

There is no danger of a fish kill from too great a concentration of fertilizer when using these platforms. In fact, small fish tend to congregate in large numbers right over the fertilizer materials, with no ill effects. Fishermen have found that these platforms also furnish excellent hiding places for large bass.

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CREEL-CENSUS AND FISHERMAN-EXPENDITURE STUDIES

As part of a program undertaken to provide information concerning the fishing pressure, yield, expenditures by fishermen, and comparative worth of various types of fisheries in the Missouri River Basin, the U. S. Fish and Wildlife Service conducted a study on the North Fork Sun River and several associated bodies of water in Montana during 1951 and conducted a similar study on the 140-mile Madison River in Montana during the summers of 1950, 1951, and 1952. The data are now available as processed papers:

Creel census and expenditure study, North Fork Sun River, Montana, 1951.--Prepared in Office of Missouri River Basin Studies, Billings, Montana.
Spec. Sci. Rept., Fish. 120
39 pp., illus. May 1954.

Creel census and expenditure study, Madison River, Montana, 1950-52.--Prepared in Office of Missouri River Basin Studies, Billings, Montana.
Spec. Sci. Rept., Fish. 126
40 pp., illus. April 1954.

The U. S. Fish and Wildlife Service and the Ohio Division of Wildlife of the Department of Natural Resources have recently undertaken a cooperative investigation known as The Hebron Farm Pond Project.

The project has two major objectives: first, establishment of practical methods for stocking and otherwise managing farm fishponds in Ohio; and second, training of personnel in farm-pond management and demonstration of pond management practices to interested groups and individuals.

A center of operations for the program will be the U. S. Fish-Cultural Station at Hebron, Ohio. At this station a number of 1-acre ponds have been set aside for the experimental work necessary to work out optimum stocking ratios and management practices. In the next 3 years populations in these ponds will be seined only to check reproduction, balance, and growth rates.

In 13 months at the Thai Government Bangkhen Fisheries Station, the net harvest from a demonstration pond represented 6.8 tons of tilapia per acre per annum.

The possibility of profitable production of tilapia in the United States seems very doubtful. Tilapia quickly overpopulate a pond and thus produce great numbers of small fish, for which there is no market here. Also, as tilapia do not tolerate temperatures below 50° to 55° F., they would be winterkilled except in the deep South. And, given proper conditions, some of our sunfishes grow larger in less time.

A REPORT ON THE MISSISSIPPI THREADFIN SHAD

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and
J. Bruce Kimsey, California Department of Fish and Game, Sacramento, California

THE MISSISSIPPI THREADFIN SHAD, Signalosa petenensis atchafaylae Evermann and Kendall, has in recent years caused considerable speculation among fishery workers. Little has been published about the threadfin shad, and the authors feel that recent information on its status as a forage fish should be made available.

Several subspecies of threadfin shad are native to the gulf region from Florida to Texas, the lower Mississippi River drainage, and Mexican waters. The most northern of these subspecies, the Mississippi threadfin, is common in mainstream impoundments of the Tennessee River in Kentucky, Tennessee, Mississippi, and Alabama. However, no threadfin shad have been found in the Cumberland River, which drains much of eastern Kentucky and middle Tennessee and flows into the Ohio River 16 miles above the mouth of the Tennessee River.

Except for its smaller size, yellow fins, longer prominent dorsal ray, and more terminal mouth, the threadfin shad is similar in appearance to the gizzard shad, Dorosoma cepedianum (LeSueur).

In the Tennessee River, threadfin shad are found only where the gizzard shad, Dorosoma cepedianum (LeSueur), and the skipjack, Pomolobus chrysochloris Rafinesque, are also abundant. Therefore, the value of the threadfin shad as a forage fish has been difficult to determine. Much more can be learned if this fish can be successfully introduced into waters where the gizzard shad and skipjack are not found. The skipjack feeds heavily on the threadfin shad, and this may limit the number of shad available to the game fish.

Threadfin shad appear to be an ideal forage fish. They are short lived--few reach 2 years of age--and seldom reach 7 inches in length. They are generally pelagic and often feed and migrate in schools numbering many thousands. In fall and spring they congregate in large numbers below the dams. Fishing for white bass, sauger, and crappie is especially good at such times.

The general interest in stocking the threadfin shad in Tennessee and in other States has led to considerable work on the problem of transportation. This fish is extremely fragile, and high mortality during transport is to be expected. Preparatory to the shipment of threadfin shad to California by air, several days were spent

Top: Gizzard shad of average size (10 inches) in Tennessee.
Bottom: Threadfin shad of average size ($5\frac{1}{2}$ inches) in Tennessee.
(Photo courtesy the authors)

in experiments made to determine the best methods of transport. Although the tests were limited in extent, and some of the data were inconclusive, several important observations that may be helpful to others were recorded.

The Mississippi threadfin shad suffer high mortality when exposed to low water temperatures or sudden changes in water temperature. In the Tennessee River they are found only in the large, low-elevation reservoirs where water temperatures are relatively stable. Even here, however, there is often heavy mortality when the temperature drops suddenly.

In the experiments, maintenance of stable water temperatures proved to be an important survival factor. Shad held 24 hours or more showed highest survival when the water temperatures were maintained between 50° and 60° F. No water above 65° F. was available for the experiment. High mortality occurred when water temperatures were decreased below 45° F. Very few fish survived water temperatures below 40° F. No fish survived when the water was allowed to freeze over.

Threadfin shad also showed high mortality when crowded. Survival was highest in the transport containers when the fish were few enough to insure adequate natural oxygen. Aeration seemed to agitate the fish and it lowered water temperatures dangerously during cold weather. Apparently the methods of aeration available for the experiments were inadequate or harmful. There was evidence that the fine misting of the air was particularly harmful to the fish. The resultant coating of the fine bubbles on the gill filaments may have prevented an efficient exchange of gases.

When transported or held under confinement, threadfin shad are extremely active. Sodium amytal, a sedative used successfully in California to decrease the metabolism and oxygen demands of trout during transportation, did not appear to quiet the fish or increase their survival. There was some indication that survival was improved when transport containers rested on foam-rubber pads. Apparently decreased vibration lessened the agitation of the shad.

The experiments in Tennessee indicate that approximately 100 of the 5- to 6-inch threadfin shad can be transported in a 25-gallon container with no added sedative or oxygen. Temperatures should be held between 50° and 60° F. Fifty threadfin shad carried well in a 10-gallon milk can. Survival under such conditions over a 24-hour period may range from 5 to 50 percent for each container. Some shad were held as long as 3 days, but with almost complete mortality. Maintaining a current of water in the tank appeared beneficial. The fish orientated themselves against the current and were less agitated than when held in regular containers without a current.

During recent years several States have introduced threadfin shad into their waters with varying results. In Kansas, threadfin shad introduced into a pond during the spring reproduced successfully but failed to survive the next winter. The results of the introductions in Virginia are not known.

Threadfin shad were stocked successfully in Watauga Reservoir in eastern Tennessee. Approximately 200 yearlings, introduced in May 1953, reproduced successfully in the same year. By fall, large numbers of young-of-the-year threadfin shad came through the penstocks and turbines of the powerhouse. Many schools of threadfin shad were also observed in the reservoir. As Watauga Reservoir is a storage impoundment at a relatively high elevation, there is some question whether they will survive a relatively cold winter.

Some infertile reservoirs, 20 to 350 acres in size, in Tennessee have recently been stocked with threadfin shad; how successfully, is yet to be determined.

Research by biologists of the California Inland Fisheries Branch has indicated that lack of a suitable forage species is probably the greatest deterrent to warm-water fishing in that State's fluctuation reservoirs. Rapid drawdown frequently limits the spawning success of present forage species and virtually eliminates food production in the important littoral zone. It

appears that since the threadfin shad is not dependent upon this unstable littoral zone at any time during its life cycle, this fish may be an answer to the forage-fish problem in fluctuating reservoirs.

The threadfin shad taken to California from Chickamauga Reservoir in Tennessee are being held in San Diego County brood ponds. Their progeny will be stocked experimentally in a fluctuating reservoir in that area. Other waters in California and waters in several other western States are also being considered for stocking. The success of these experimental introductions will probably be reported in the literature.

UNUSED RESOURCES OF LAKE ERIE

The deplorable failure to utilize efficiently the great fishery resources that are available from Lake Erie has been pointed out by Dr. James W. Moffett, chief, Great Lakes Fishery Investigations, U. S. Fish and Wildlife Service:

"At the inception of the fishery on Lake Erie, cisco, sturgeon, and whitefish were the chief varieties in the catches. Further development brought other species into the commercial markets, but at no given time were more than 10 species of really major importance in the production from that lake. More or less heavy fishing pressure has been kept on these species, while some 90 to 100 other species known to inhabit the lake have not been harvested to any significant degree. Among the species unimportant to the fishery are many which are extremely abundant and which compete with, or prey on, at least some life stages of the commercially important fishes. These species probably expand to fill the environmental niches occupied by the kinds removed by man--and thereby make more difficult the survival of the stocks and the perpetuation of the fishery.

"Much of the productive capacity of Lake Erie and of the other Great Lakes is undoubtedly being 'diverted' into the production of 'trash' fish or small species of no market value and thus no longer contributes to stocks of value to the fishery. This situation emphasizes the contrast between basic biological productivity and the 'dollar' productivity of concern to the fishery. Many facts lend credibility to the belief that Lake Erie is more productive, biologically, now than it has ever been although it is not producing catches of value to fishermen in the same measure as formerly."

Sea gulls have been responsible for a considerable loss of silver salmon at the U. S. Fish-Cultural Station at Little White Salmon, Washington.

The birds have been in the habit of following the spawning chinook salmon up the Little White Salmon River from Drano Lake. Then, as soon as the spawning of the chinooks is completed, the gulls have moved back into Drano Lake or even into the Columbia River in search of more food.

During the past year, however, at the conclusion of the chinook spawning, the sea gulls were attracted to silver salmon that, for the first time, were being held in the rearing ponds at Little White Salmon for use in an experiment. Here the birds found the feeding good, and they remained to do a great deal of damage.

"At the first of the year these salmon were 4 inches long," reports H. B. Cox, superintendent, "and any loss could have been hand-counted easily. But, though there was almost no loss by death from other causes, we lost more than 22,000 of these silver salmon to sea gulls during the winter."

USE OF URETHANE ANESTHESIA IN SPAWNING EASTERN BROOK TROUT

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THE USE OF URETHANE ANESTHESIA to facilitate the handling of fish has been common practice in Wisconsin since the report by Gerking (1949). Urethane anesthesia has proved a reliable and convenient aid in removing fins of trout, yellow walleye, muskellunge, bass, and panfish. Preliminary experiments in 1949 showed promise for its use in spawning procedures, but the method was not developed further at that time.

During September 1953 an experiment was conducted at the Osceola hatchery to determine the value of urethane for the taking of spawn from eastern brook trout. The objectives were (1) to record any reduction in work time attributable to the use of anesthesia; (2) to compare the percentage hatch of eggs and the survival of brood fish, using spawning methods with and without urethane anesthesia; and (3) to determine the effects of daily anesthesia on the same individual trout.

Methods

A waist-high spawning table that held running water and the trout to be spawned was used for the experiment. Two metal pans, approximately 16 by 17 by 6 inches, were constructed to fit into the midsection of this spawning table. Winged fasteners kept the pans from floating up. A 2-gallon solution of 0.5 percent urethane was mixed into each pan, and female and male trout were anesthetized in the separate containers. No trout remained in this solution longer than 18 minutes. As it was felt that urethane might have some deleterious effect on the fertility of the eggs, these and the milt were stripped carefully in order to reduce the drip of urethane water into the egg pans. (See figure.)

Two spawn-takers, each of whom had more than 10 years' experience, stripped all of the eggs. After approximately a week of the standard procedure, the urethane was included in the routine. A stopwatch was used to time the interval from the dipnetting of the first trout to the completion of the final egg washing.

Records on survival of anesthetized males were not kept because these had to

Trout were stripped with care in order to reduce the drip of urethane water into the egg pan.
(Photo courtesy the author)

be re-used in successive spawnings. The records, therefore, included only survival of the female trout.

The re-use of males made it important to know the tolerance to daily anesthesia. Five selected eastern brook trout were subjected to an 18-minute immersion in 0.5 percent urethane on 15 consecutive days.

Results

The spawn-takers, after orientation to the use of urethane for spawning trout, demonstrated an approximate 25-percent reduction in work time for the new method (table 1). Without anesthesia, handling 100 trout had required 42 to 45 minutes. With urethane, the time was reduced to 31 to 32 minutes per 100 trout because the anesthetized fish lay still and it was not necessary to fight them. When use of urethane was discontinued, it again took the men longer to spawn the trout. Size of the trout made no difference in spawning time, for 1.5-pound adults were handled as quickly as 0.5-pound 2-year-old fish.

The percentage of egg hatch and brood-stock survival were similar for groups handled with and without urethane anesthesia (table 2). A slightly higher egg hatch (93.2 percent, as compared to 92.5 percent) was recorded for anesthetized fish. Survival of female trout of comparable age, with and without urethane anesthesia, was 93.1 and 93.3 percent, respectively. Autopsies of trout over a 3-month period showed that all deaths could have been due to other causes, not to use of anesthesia.

Trout given urethane anesthesia daily were tolerant to it. The 5 selected trout survived an 18-minute immersion in 0.5-percent solution on 15 consecutive days with no mortality or undesirable symptoms. These trout were autopsied, and their internal organs appeared identical to those of trout that had not been subjected to the urethane, indicating that repeated use of it on males was not harmful.

Use of urethane in spawning trout resulted in a saving of time without affecting adversely the hatch of eggs or the survival of the brood stock. The reduction in work time and the fact that hatchery personnel were much pleased with its use may well recommend urethane anesthesia for future trout spawning operations.

TABLE 1.--Work-time reduction attributable to use of urethane anesthesia in taking trout spawn

Date (Sept. 1953)	Number spawned	Time per 100 trout (minutes)
	Without urethane	
23	219	45
29	635	43
30	343	42
	With urethane	
24	73	41
25	287	31
28	205	32

TABLE 2.--Hatch of eggs and survival of female brood stock with different spawning procedures

[Survival of brood stock recorded for 3 months after spawning]

	Without urethane	With urethane
Number eggs spawned	1,367,520	425,820
Percentage hatched	92.5	93.2
Number trout spawned	1,116	276
Percentage survival	93.3	93.1

Acknowledgments

The author wishes to thank Dr. E. L. Cooper for his helpful suggestions, and Mr. Locy Stewart (Osceola hatchery foreman), Mr. Howard Berquist (St. Croix Falls hatchery foreman), and Messrs. Louis Leish and Lawrence Hoovermen (spawn-takers) for their splendid cooperation in making this experiment possible.

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DIVIDENDS FROM RESEARCH

TAPEWORM INFECTION IN LESSER SLAVE LAKE

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Lesser Slave Lake, Alberta, is a large producer of whitefish and ciscoes. The former are sold for human consumption, and the latter are used mainly as food for ranch-raised mink. In the 1930's and early in the 1940's, the occurrence of great numbers of cysts of the tapeworm, Triaenophorus crassus, on both these fishes was becoming increasingly well known to the consuming public, and--though the worm is harmless--the market fell off very seriously.

A detailed study of the life cycle of the worm was started in 1939. Among other things, it was observed during this study that infection came from eating infected plankton, and that, as a result, the plankton-feeding ciscoes were much more heavily infected than the bottom-feeding whitefish. It was also observed that the ciscoes remained fairly free of infection until their third year of life. These observations led to an experiment in which all restrictions on the catching of ciscoes were removed. It was hoped that the ciscoes would be overfished to the point where the older and wormier age-groups were completely removed; theoretically, with this accomplished, the whitefish should "come clean," the chief reservoir of tapeworms thus removed.

The experiment paid off in 4 years. The ciscoes were fished down to 2-year-olds, and the whitefish became almost entirely free of infection and fully acceptable on the market.

OTTER-TRAWL MESH EXPERIMENTS WITH DOVER SOLE

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The otter-trawl fishery of Oregon produces some 20 to 30 million pounds of bottom fish annually. This represents approximately 25 to 30 species of flat and round fish. During the postwar years the Dover sole (Microstomus pacificus) has been the principal flatfish sought by the fishermen. An average of approximately 4 million pounds of this species was landed annually in the period 1946-52. The peak year was 1951, during which 8.5 million pounds were landed.

The fillet plants impose a minimum size upon each species of sole that they purchase, basing these sizes on a profitable return of filleted meat from the whole fish. The fishermen in turn select for their nets a mesh size that will insure the capture of all, or practically all, the sole equal to and larger than these minimum sizes. Unfortunately, the selective action of the nets is such that a considerable number of fish smaller than the minimum size are also caught and must be sorted from the catches and discarded at sea. Most, if not all, of these fish are dead when discarded.

The States of Oregon, Washington, and California, working under the auspices of the Pacific Marine Fisheries Commission, a coordinating body for mutual fishery problems of the three States, undertook cooperative mesh experiments aboard a vessel of the California Fish and Game Department. These experiments were designed to determine, if possible, a

mesh size that would minimize the waste of young sole at sea. In the catches made with experimental nets, the proportion of marketable fish in the total catch ranged from 31 percent with a 3-inch mesh to 98 percent with a 4.5-inch mesh. However, for any single mesh size the percentage of marketable fish in the catch varied, presumably owing to change in size composition of fish on the grounds.

As a result of these and some earlier studies, a minimum mesh size of 4.5 inches (measured between the knots) was adopted by the Fish Commission of Oregon to become effective in 1954.

From studies made of the discard at sea by commercial vessels, the "average" discard of Dover sole in 1953 was estimated to be 25 percent by number. In making this estimation, the various mesh sizes used by members of the Oregon fleet have been taken into consideration.

The total catch of Dover sole in Oregon for the period 1946-52 was 33.1 million pounds, equivalent to 16.6 million fish. If 25 percent is a reasonable estimate of the discard at sea, 5.5 million small Dover sole were wasted during this 7-year period.

As most of these discarded fish would have reached a marketable size in 2 or 3 years, and were capable of doubling their weight in 5 years, the loss to the fishermen was significant.

It is believed that this minimum-mesh-size regulation will materially help the fishermen to utilize their fishery resource more economically.

TO LOOK AND SEE PAID OFF IN THE TENNESSEE VALLEY

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When the Tennessee Valley Authority began to build multipurpose dams on the Tennessee River and tributary streams in 1933, people all over the United States became interested because they were concerned over the fate of the fishery in these waters. Actually, these people did not know, or particularly care to know, what the status of this resource was before impoundment. However, they were convinced that whether or not the fish fauna thrived before impoundment, the use of water for flood control, navigation, and power was noncompatible with fish life. A drawdown of 6 to 10 feet on mainstream dams was bad enough, but certainly no fishery could exist with recessions of 60 to 100 to 150 feet! (They did not stop to consider that the time of recession might be of utmost importance.) Under these circumstances, the only hope held out by the experts (sometimes one is positively happy not to be an expert) was that through an extensive (and expensive) system of stocking and the most rigid regulation some kind of fishing could be maintained.

TVA, anxious to do the right thing, proceeded on the basis of these recommendations--built hatcheries, built rearing ponds, and encouraged the States to tighten fishing regulations. Fortunately, however, TVA did not stop here but began a look-see program. Creel census showed that most of the fish were taken early in the open season. An experimental open season (during the regular closed season) showed that roughly twice as many fish were taken during this period as during the rest of the summer. Fish tagging and tag recovery showed that only about 10 percent of the available fish crop was harvested. Other studies showed that during years in which the fishing was good when the season opened June 1, most of the bass had not spawned. If this situation existed, then why have a closed season, artificial stocking, and restriction on the catch?

As far as the TVA dams are concerned, what has been the payoff on these studies? (1) Waters impounded by man for multipurpose use produce fish; (2) no money is spent on fish propagation; (3) regulations have been liberalized so that people can fish the year around with a minimum of attention to size and creel limits, resulting in greatly increased harvest; and (4)

revenue from the sale of fishing licenses has increased very substantially. Thus, the Tennessee Game and Fish Commission sold 57,387 licenses during the 1934-35 season, and the corresponding figure for 1952-53 was 759,397, an increase of more than 1,200 percent. In the same period the income from sales of nonresident fishing licenses rose from $1,600 to approximately $250,000.

The liberalizations mentioned in the preceding paragraph were put into effect because it was obvious that the fishery was underexploited--but also because it was felt that should overfishing result, the rapid growth rate that TVA workers had demonstrated for bass, crappie, and walleye would furnish a ready tool to correct this situation in a closed season imposed during only one year.

As in all other bodies of water, fishing on TVA lakes is not always good. Studies of (1) the feeding habits of the fish, especially with reference to spawning; (2) the available food supply; and (3) the vertical distribution of the fish showed why fishing was good in the spring, relatively poor in July and August, and improved again in September or October. A look-see showed also that water stratification with respect to temperature, 0_2, influenced by density currents affected the vertical distribution of fish.

MESH REGULATION IN THE NEW ENGLAND HADDOCK FISHERY

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Ever since the trawl net was brought into New England, fishermen have been catching groundfish with small mesh nets. These nets caught and killed large quantities of immature fish that were too small to market. Was this destruction injurious to the fishery? At just what size should the fishermen take the fish, and in what quantity? To answer these questions for the haddock fishery, the U. S. Fish and Wildlife Service conducted studies of the haddock population on Georges Bank over a period of years and finally recommended that the present fleet could fish as hard as it pleased provided that it did not take fish under 2-1/2 years of age. To allow the small fish to escape, it was recommended that the size of mesh in the cod ends of the nets be increased from the commonly used 2-7/8 inches to 4-1/2 inches.

An international regulation requiring a minimum size of 4-1/2 inches went into effect June 1, 1953. It was expected that the initial result of this regulation would be a slight decrease in landings because of the escape of some marketable-size fish through the larger mesh. It was believed, however, that the regulation would have the ultimate advantage of an increase in landings amounting to about 30 percent. This advantage will not be fully realized for several years.

Conversion to use of the new mesh was gradual and not completed until October 1. On June 1, in order to provide information necessary for testing the effect of the new regulation, eight large trawlers were licensed to fish with the small mesh. Observers were sent to sea on both large-mesh and small-mesh boats in order to sample the fish discarded as well as those landed.

The expected initial decrease in the landings has not occurred. Instead, the large-mesh boats have enjoyed a definite advantage beginning at the time of conversion. During the last 3 months of 1953, landings per trip of all species averaged 8,000 pounds more than those of small-mesh boats. Haddock alone has averaged 2,000 pounds per trip more for the large-mesh boats. The discard by the large-mesh vessels has been almost negligible (figures 1 and 2). Though the large-mesh boats have caught less of the smaller marketable sizes, this disadvantage has been outweighed by a greater catch of the larger sizes of haddock (figures 1 and 2).

Comparisons of individual catches by boats for similar periods in 1952 and 1953 show the same advantage in using large-mesh nets. The catch of haddock from

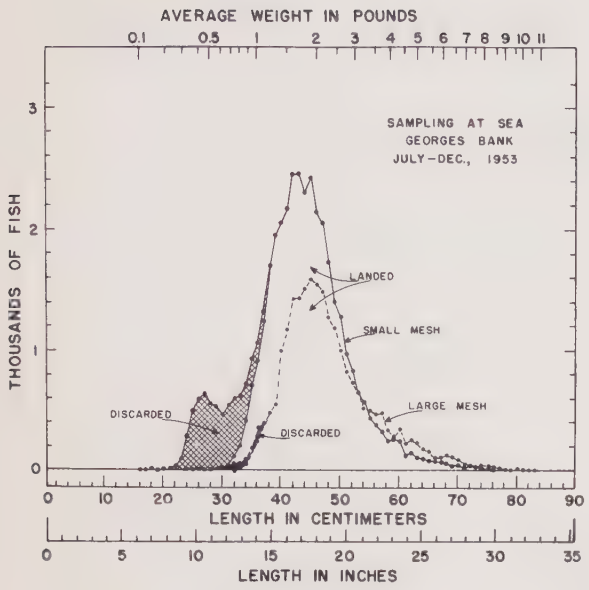

FIGURE 1.--Size composition of catch of 14 observed trips, July to December 1953. Vertical scale represents numbers of fish taken by each group of boats.

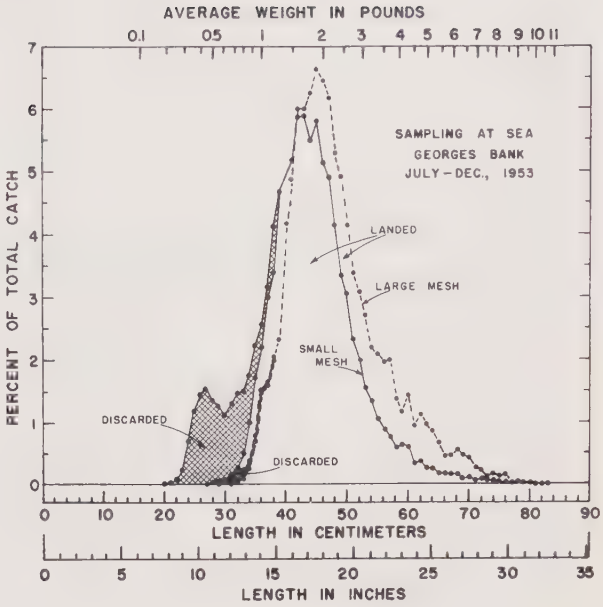

FIGURE 2.--Size composition of catch of 14 observed trips, July to December 1953. Vertical scale in percent of total catch of each group of boats.

Georges Bank during the last 3 months of 1953 was down for all vessels but to a greater degree for the small-mesh boats. The total catch of all species held steady for the large-mesh boats but was down about 10 percent for the licensed small-mesh boats.

Total landings of groundfish at Boston in the last 3 months of 1953 were about 33 million pounds, worth about 3 million dollars as landed. Without the mesh regulation, this would have been about 10 percent less, or down about 3 hundred thousand dollars. At this rate, benefits amount to about 1 million dollars yearly, assuming that the net has the same beneficial effect on the Nova Scotia Banks, where a large portion of the Boston fleet fishes.

The greater efficiency of the large-mesh net was not unexpected. Experiments in England and in this country had indicated a certain advantage of larger meshes. When the advantage was first noted in our commercial fleet, however, it was thought that the larger catches with the new net might possibly be ascribed to a change in fishing habits--a change which would have the large-mesh boats fishing deeper water to avoid concentrations of smaller haddock in more shallow depths. Nevertheless, a close study of trip records shows no difference in the distribution of fishing effort by the large-mesh and small-mesh boats. The advantage, therefore, must be ascribed to the greater efficiency of the larger mesh. Our calculations indicate that the pressure on the larger sizes can be increased as much as 25 percent without diminishing the sustained yield. This conservation measure, then, is paying off in two ways: it is saving the small fish for later capture and is increasing the catch per unit of effort of the marketable sizes. The Georges Bank population is being restored while the efficiency of cropping has been improved.

REVIEWS

ÉTUDE EXPÉRIMENTALE DU DÉTERMINISME DE LA RÉGÉNÉRATION DES NAGEOIRES CHEZ LES POISSONS TÉLÉOSTÉENS

Jacqueline Buser-Lahaye
Annales de l'Institut Océanographique (Monaco), nouvelle serie,
tome 28, fascicule 1, 61 pp., 25 figs., 19 tables. Paris, Masson et Cie., 1953.

The removal of one or a combination of fins is the tool most commonly used by fishery biologists to mark a group of fish for later recognition--not as individuals, it is true, but as a year class or a group which was stocked or subjected to some other treatment simultaneously. Thus it is not surprising that a fair amount of experimental work and even more observational effort have gone into assessing the subsequent fate of fin-clipped fish--their rate of growth, survival, and so on.

The results of such work in the last 15 years or so are by no means clear-cut. Ricker stressed the cumulative effects of small disadvantages which may, over more than one season of competition and predation, work to the serious detriment of a group of fin-clipped fish.[1/] Shetter, observing his animals for shorter periods of time, found that fin-clipping by and large neither impaired the growth nor made experimental fish more vulnerable to predation than his controls.[2/] Further, there have been numerous unpublished instances in which fishery biologists, dealing with variations in behavior and growth, as between marked and unmarked fish, would look upon the only apparent difference--clipped fins--as the cause of such variation, availing themselves of the often useful but always suspect "post hoc, ergo propter hoc" (subsequent to this, therefore caused by this) manner of reasoning.

A series of experiments dealing with the effects of controlled environmental variables on fin regeneration is therefore of utmost importance. These experiments have been performed by Buser-Lahaye, and the results to be discussed here are clear-cut and interesting. They promise to be of considerable help to the field-worker and they substantially increase our knowledge of fish physiology.

Here fins were removed singly or in combination from a number of fresh-water fishes (Ameiurus nebulosus, Cyprinus carpio, Gobio gobio, Phoxinus phoxinus, Xiphophorus hellerii, Lebistes reticulatus, and Gambusia holbrooki) as well as from marine teleosts (Julis vulgaris, Mugil capito, Mugil auratus, Gobius capito, Heliastes chromis, Serranus cabrilla, and Scorpaena scrofa). Most of the detailed work was done on Gambusia, Ameiurus, and Mugil. The fins were removed with a very sharp instrument a few millimeters from the base so as to avoid scarring the body. Measurements were taken at regular daily or weekly intervals, on small fishes under the microscope and on the large ones with calipers.

1/ Ricker, W. E. 1949. Effects of the removal of fins upon growth and survival of spinyrayed fishes. Jour. Wildl. Mgt. 13 (1): 29-40.

2/ Shetter, D. S. 1951. The effect of fin removal on fingerling lake trout (Cristivomer namaycush). Trans. Am. Fish. Soc. 80 (1950): 260-277.

1952. The mortality and growth of marked and unmarked lake trout fingerlings in presence of predators. Trans. Am. Fish. Soc. 81 (1951): 17-34.

The rate of regeneration, expressed in percentage, was obtained by taking the ratio of regenerated fin length to its total length before amputation; thus the speed of restoration could be plotted against time. All experiments were made in aquaria, some in flowing water and some in standing water. The following conditions were studied:

(1) Temperature. This ranged generally between 17° and 30° C., though a few experiments were done with waters as low as 10° C.

(2) Light. Only white light was used; the effect of varying periods of illumination on fin regeneration was tested.

(3) The relative importance of temperature and light was investigated.

(4) Internal factors. The roles of the thyroid and pituitary glands were given special attention.

EXPERIMENTAL FINDINGS

It was found that regeneration, when it occurs, is preceded at all times by the formation of scar tissue, most noticeably in cases of retarded regeneration. Spiny and soft rays differ as to speed and ease of regeneration. This was especially apparent on bullheads, where a section of pectoral or dorsal fins would affect both types of fin rays. Whether this retardation was due to the more irregular section of the thicker bony element or to other causes was not ascertained.

The removal of caudal fins of Gambusia at various levels revealed that regeneration proceeds faster if less, and more slowly if more, of the fin is cut off.

A few other observations preceding the experiments proper are of interest:

(1) Young fish regenerate fins faster than adults.

(2) There is no difference in speed of regeneration (in Gambusia, at least) between the sexes. It should be mentioned, though, that one might well suspend judgment on this point until some further tests have been made.

(3) Different fins are regenerated at different rates (figure 1).

(4) The general state or condition of the fish--as would be expected--affects the speed of regeneration.

TEMPERATURE

The effects of temperature were the most spectacular. There exists, apparently, a threshold below which no regeneration takes place (figure 2). Above that

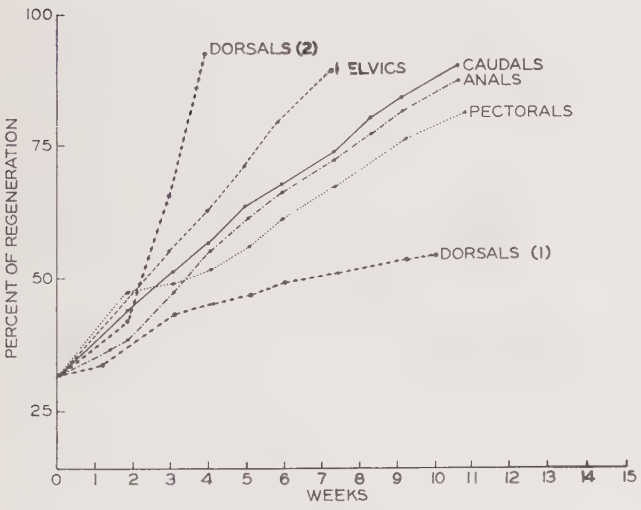

FIGURE 1.--Mugil capito: mean speed of regeneration of different fins.

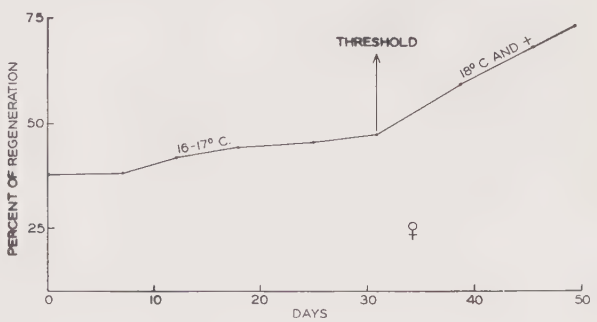

FIGURE 2.--Temperature threshold of the fin regeneration of Gambusia females in fresh water.

(Figures 1 and 2 have been adapted from Buser-Lahaye's figures 6 and 9.)

temperature, 17° C. in the experiment in which Gambusia were observed, the rate of regeneration increases in proportion to the increase of temperature (figure 3).

Black bullheads, for instance, do not begin to regenerate a fin before 3 weeks after amputation at 20° C. At 25° C., visible regeneration starts after 12 to 15 days; at 30° C., a week suffices to start new growth.

Fish acclimated to winter conditions will begin to regenerate amputated fins when the temperature increases and will stop regeneration when the temperature decreases.

LIGHT

At temperatures that were just below the threshold, continued illumination produced regeneration; but at temperatures that were around 10° C., even continued illumination did not give rise to fin regeneration on Gambusia. Complete darkness at elevated temperatures resulted in a slight increase of the rate of regeneration, but an increase in light intensity at constant temperature also seemed to increase the speed of fin regeneration (figure 4). Illumination of constant intensity and varying duration did not produce decisive results.

INTERNAL FACTORS

The thyroid gland of experimental fish responded to temperature increases by increasing activity and to decreases in temperature by regression, but varying periods of illumination did not affect the secretory state of the thyroid. It was therefore attempted to inhibit and stimulate thyroid action by biochemical means and observe the results, if any, on fin regeneration.

Pregneninolone, a highly active testosterone derivative, slowed regeneration, apparently by changing the pituitary influence on the thyroid gland; and thyroxine injections at subthreshold temperatures speeded up regeneration. Histological observations accompanied and corroborated these regeneration tests.

The thyroid, for anatomical reasons, could not be removed; but operative removal of the pituitary gland was successfully accomplished in Gobius capito and Ameiurus nebulosus.

Animals without pituitary glands did not regenerate their clipped fins and were characterized by a marked retrogression of thyroid activity and development. Thus a pituitary-thyroid mechanism of fin

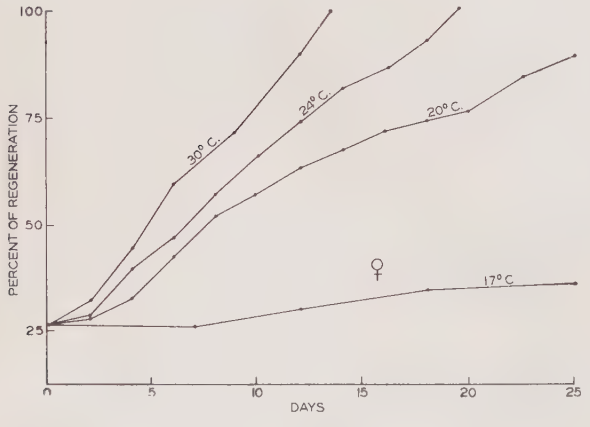

FIGURE 3.--Speed of fin regeneration at different temperatures. Gambusia females in fresh water.

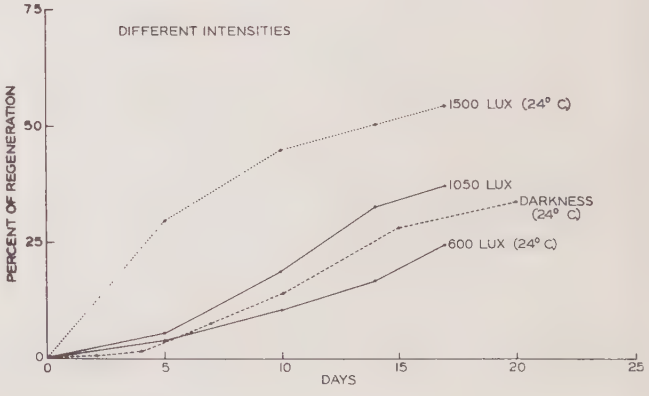

FIGURE 4.--Mean speed of regeneration of caudal fins on Gambusia females held at different light intensities.

(Figures 3 and 4 have been adapted from Buser-Lahaye's figures 10 and 13.)

regeneration and perhaps of growth phenomena in general (including scale regeneration) is to be postulated, though--as this reviewer must point out--the crucial experiments, in which animals without a pituitary gland would be given injections of thyrotrophic hormones, have not yet been performed.

In summary, the following conclusions may be stated:

(1) The experiments point to temperature and light as most important factors in fin regeneration.

(2) The regulation of regeneration, as well as perhaps other growth phenomena, proceeds through endocrine channels, with the thyroid and the pituitary as important intermediaries.

Some additional experiments suggest themselves. These studies would test the quality of light as well as the quantity and thus would compare fish at various levels of physiological activity to a greater extent than has been done in the present experiments. Also, a comparison of the mechanisms of fin and scale regeneration, observed simultaneously, would certainly be of interest. Last, but not least, similar work should be extended to trout and other decidedly cold-water species. Some of these experiments are now planned at the Department of Fisheries, University of Michigan.

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University of Michigan, Ann Arbor.

ANALYSES BIBLIOGRAPHIQUES, 1940-1950

Annales de la Station Centrale d'Hydrobiologie Appliquée
(Ministère de l'Agriculture: Direction Générale des Eaux et Forêts)
Fascicule hors série, pp. 7-175, Paris, 1953

This bibliography of French publications in hydrobiology, 1940-50, prepared by a group of collaborators working under the general supervision of Paul Vivier, forms the principal part of a special, unnumbered issue of the Annales. (Included in this same issue are three reports on original work--work on triclads, bacteria, and Hydracarina.) The contents of this volume were assembled originally for publication as a number of the Internationale Revue; but when plans for re-establishment of that journal failed, it was decided to publish the material in the Annales.

The appearance of this bibliography will be welcomed by the many American workers who have experienced difficulty in covering French literature in their field. In France, as in America, papers on hydrobiological subjects seem to be badly scattered among a large number of publication outlets--many little known and sparsely distributed outside the country of publication.

The 1,059 titles listed are accompanied by abstracts. Some of the abstracts are extremely brief, but others are comprehensive. In several instances one abstract covers a series of related articles.

The major subject headings (translated) and the numbers of papers listed are as follows:

I.	Biocoenosis of fresh water	21
II.	Lakes	21
III.	Subterranean waters	85
IV.	Brackish waters	31
V.	Botanical hydrobiology	14
VI.	Fresh-water algae	132
VII.	Protista	74
VIII.	Rotifers	6
IX.	Turbellarians	16
X.	Hirudinea	1
XI.	Fresh-water mollusks	22
XII.	Crustaceans	42
XIII.	Acarina	14
XIV.	Aquatic insects	314
XV.	Fresh-water fish	228
XVI.	Applied hydrobiology	38

The listings under some of the major headings have been subdivided. The most elaborate subdivision--and the one of most interest here--is the following for freshwater fish (again the number of titles follows the subject):

1. Migrations - 4
2. Nutrition and growth - 10
3. Regeneration - 1
4. Biogeography
   - France - 1
   - Africa - 27
   - Asia - 10
   - America - 1
5. Systematics - 5
6. Ossification - 13
7. Cranium - 5
8. Pigmentation - 18
9. Circulatory system - 2
10. Pancreas - 2
11. Blood and hemapoietic organs - 4
12. Corpuscles of Stannius, thymus, and thyroid - 5
13. Eggs - 4
14. Reproduction
    - General - 6
    - Histology - 1
    - Artificial fertilization - 2
    - Hybridization - 1
    - Embryology - 1
    - Sexual differentiation - 14
15. General physiology
    - General - 4
    - Internal environment and osmoregulation - 20
    - Biochemistry - 2
    - Vitamins - 2
15. General physiology (continued)
    - Respiration - 1
    - Circulation - 1
    - Nervous system - 4
    - Electrophysiology - 7
    - Sense of equilibrium - 7
    - Migrations - 9
    - Endocrine glands - 15
    - Reproduction - 6
    - Immunity - 1
    - Anaphylaxis - 3
    - Pharmacology - 7
    - Pathology - 2

The user of this bibliography sometimes may wonder about the logic behind certain of the subdivisions and be puzzled by the placement of individual titles. He will discover, too, that the titles under a particular heading may not include all of the titles bearing on that subject. For example, a single paper is listed under "Regeneration," but other highly significant articles on the subject appear under "Ossification." Papers on various aspects of migration are widely scattered.

Too much should not be made of these seeming defects, as they could not be avoided without excessive and complicated cross-reference. Any adverse criticism of the bibliography must appear picayune in the face of the commendation that goes to Vivier and his collaborators for rendering a valuable service.

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